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Stem(ming) from Where? A Philosophical Analysis of U.S. Mathematics Education Policies

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STEM(MING) FROM WHERE? A PHILOSOPHICAL ANALYSIS OF U.S. MATHEMATICS EDUCATION POLICIES

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ABSTRACT

STEM(MING) FROM WHERE? A PHILOSOPHICAL ANALYSIS OF U.S. MATHEMATICS EDUCATION POLICIES

by Nataly Z. Chesky

Much attention has been placed on mathematics education in U.S. education policy reform discourses. Most recently, the emphasis has been on connecting mathematics with science, technology, and engineering, termed The STEM Initiative. Although a great deal of research has been conducted to understand how to meet the objectives of STEM, studies are limited in their focus and rarely question the philosophical assumptions inherent in policies. This is a mistake since mathematics is a field of knowledge deeply entrenched in historical, cultural, and philosophical perspectives.

A content analysis study of mathematics education policy, this dissertation employs a philosophical perspective, influenced by the contemporary philosopher Alain Badiou, in order to explore the philosophical categories found in publically disseminated national policy documents about mathematics education in the U.S. In this dissertation study I examined the ontological assumptions, epistemological claims, and axiological objectives that can be found in current U.S. mathematics education policies. I asked what societal and political consequences can ensue from the way in which mathematics is conceptualized in educational policy discourse and what implications this discourse has on public school professionals teaching mathematics today.

The findings of this dissertation study move the diverse debates in mathematics education by offering a more complex picture of the structure by which our society values mathematics and prescribes how it should be learned. Ultimately, it is the hope of the researcher that this work helps provide agency to educators working in the field, so that they may have the necessary knowledge about the intricacies of the policies that they themselves are responsible to implement, as well as the added philosophical knowledge to invigorate the mathematics classroom with the potentiality for radical changes in the way students come to understand and later use mathematics in their lives.

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Chapter 1: Introduction

1.1. Introduction

Mathematics is both a highly contested domain of knowledge and an extremely valued one. Traditionally, it is contested on epistemological/ontological grounds in philosophy of mathematics and on ethical/political grounds in philosophy of education. Notwithstanding these academic disputes, mathematics is unanimously valued in the western world as a societal good as well as an educational necessity (Burbaker, 2008). The connection between a good for society and the teaching and learning of mathematics as educational imperative is understandable since what is thought to be a good for society is generally valued in education. In the United States today, this statement is truer than ever before, as evidenced by the fear, propagated by media outlets and national agencies of a declining U.S. global dominance in a free market economy (e.g. Apple, 1992; Berlinner & Biddle, 1995; Gabbard, 2007). To combat the perceived urgency for maintaining economic superiority in innovation and technology on the world stage, the education of mathematics, integrated with science, engineering, and technology (termed the "STEM" education initiative) is arguably the United States' most important educational policy reform of the 21st century.

The educational acronym "STEM" not only represents a new mathematics education reform policy but also a multi-disciplinary education perspective that combines the disciplines of science, technology, and engineering with mathematics. This may be significant since past policy reforms, which were also concerned about the need to maintain global competitiveness, concentrated on mathematics, foreign language, and science education (Klein, 2003). What is unique about STEM is that mathematics and science are no longer enough for knowledge acquisition of a modern citizen, but must be intertwined with technology and engineering. These latter fields differ substantially from mathematics, which included abstract thinking that does not necessarily apply to practical uses. This turn in policy discourse may imply a crucial turn in the way our society values and teaches students about mathematics.

Discrepancies in how a particular discipline is understood may not match the way it is taught through compulsory schooling, nor may it match the way in which a discipline interacts with societal norms that are themselves structured around particular epistemological positions. It seems valid to believe that when axiological objectives change, as happens in policy changes, the pedagogical practices and the epistemological claims that underwrite them would as well. This is not the case in mathematics education reforms, at least in the U.S.'s educational reform history. Interestingly, traditional epistemologies, which posit that knowledge of mathematics exists outside of each individual learner and thus must be learned through memorization, drills, and other cognitive apparatuses that aim to produce knowledgeable mathematics learners from otherwise math illiterate students, are still are quite prevalent in pedagogical practices in the U.S. However, even though traditional epistemologies are increasingly replaced by constructivists' pedagogies, which posit that the individual student actively creates knowledge and thus must learn mathematics through an exploratory authentic hands-on manner using manipulatives and open ended real life problems, the axiological objectives that constructivists' pedagogies are suppose to serve are similar to the ones present in justifying traditional epistemologies.

The differences between the above pedagogies are substantial, yet they are both present in policy reform discourses, which at least on the surface, have similar axiological objectives. Perhaps this ambiguity in policy is a shortcoming, which causes policies once they are implemented to not meet their desired goals; on the other hand, perhaps the ambiguity is a strength, allowing for many interpretations during the implementation process at various contextual sites. Another alternative is that there might not be any ambiguity at all if both these claims rest upon similar foundational views about mathematics. Yet a fourth possibility is that although there is an ambiguity in the way policies recommend specific pedagogies to meet specific goals, the complexity of the discipline of mathematics education necessitates such ambiguity in order to achieve the best practices for the teaching and learning of mathematics.

Solely examining the connection between epistemology and axiology in mathematics education policy reforms cannot solve the above riddle or suggest which alternative is the most sound. This is because there are implicit ontological assumptions that are foundational to both epistemological claims on knowledge acquisition and axiological objectives that dictate the ends and means of mathematics education. What is needed is an investigation into the very presuppositions or assumptions latent in the policies themselves about what mathematics is. To speak of presuppositions and assumptions, refers to the branch of philosophy called ontology. Although ontology is a relatively unheard of term in educational discourses today, it is integral in both philosophy of mathematics and philosophy of education discourses. Ontological inquiry identifies types of objects/processes/entities we posit to exist. In mathematics, such presentations are the foundation for conceptualizing a particular view of what mathematics is, how it can be taught successfully, and for what purposes it can be used. Understanding the ontological worldview present in policy documents can enable educational researchers and stakeholders to critique as well as conceptualize alternatives to policy reforms in mathematics education.

It is this ontological view that is often overlooked in policy analysis, simply because it may be seen as unimportant or be misunderstood. To illustrate this point I offer two short examples that describe ontological views of mathematics. To understand mathematics in a transcendental Platonic sense, as the ancient Greeks did, mathematics is a field of absolute knowledge that exists regardless of human understanding or cultural influence. In this ontological view, mathematical objects such as numbers and functions are absolute and precise in definition and static in their application. Teaching practices that reflect such a view would rely on rote learning and drills to ensure students develop the essential basic mathematical facts early on. It also would be categorized as having a reliance on numerical data and quantitative analysis, so much so that the numerical data generated through quantitative analysis would be viewed as valid and objective. However, mathematics understood this way might not be the sole means to economic success either for the individual competing for jobs or for the nation trying to maintain global superiority at the world free market stage. Instead, the primary purpose would be to raise our understanding of the world around us and imagine what may transcend it. The opposite of a Platonic view of mathematics, is the fallibilistic view. Fallibilistic ontological assumptions stress the human element in culture and society that influences the way mathematics is not only taught, but how its knowledge evolves through new inventions and cultural values. Mathematics understood this way would seek pragmatic ways to enrich human life and therefore seek to use mathematical knowledge in utilitarian ways that can help a person get a job or keep a nation strong. Although a fallibilistic ontological view of mathematics seems to fit better with constructivist epistemologies rather than traditional ones, it is not clear if such ontological assumptions are present in the policies that specify a constructivist epistemic stance on teaching and learning.

These above examples of how axiology, epistemology, and ontology relate to policy reform efforts in education demonstrate the importance of making these connections. In this dissertation study I examined the ontological assumptions, epistemological claims, and axiological objectives that can be found in current U.S. mathematics education policies. I investigated the cohesiveness of the policies; in other words, I examined how these different philosophical strands (axiological objectives, epistemological claims, and ontological assumptions) were related to one another in policy discourses regarding mathematics education. Once I learned more about the ontological assumptions embedded in policy discourses, I asked what societal and political consequences can ensue from the way in which mathematics is conceptualized in educational policy discourse and what implications this discourse has on public school professionals teaching mathematics today.

The broad objective of this dissertation study was to provide original knowledge that can aid policy makers, education researchers, and public school professionals in their continuing mission to improve K-12 mathematics education in the United States. Contextually, the work is situated in the United States public education system that is increasingly focused on technology and engineering skills as well as a high level of science and mathematics knowledge. The empirical focus of this study was to investigate the coherency present in national U.S. mathematics education policy documents that were made public within the last decade. Coherency, in this dissertation, is concerned with analyzing the relationship between the way in which the policy discourse stipulates what are the best pedagogical methods (means) for teaching mathematics in order to ensure a particular outcome (ends), such as more mathematically literate citizens and which foundational assumptions about mathematics guide such decisions, values, and overall objectives. Another way of analyzing policy for coherency is alignment, which asks by what degree do various policy instruments available to the system, e.g. standards, textbooks, and assessments, accord with each other and with school practice (Fuhrman, 1993; Smith and O'Day, 1993). Yet another definition of coherence focuses on school organization, issues of organization focus, an articulated vision, and a common culture of values become important in defining a coherent system (Coleman et al, 1982; Newmann et al., 2001). This definition, while central to the problems inherent in policy implementation, is not relevant to this dissertation study, which seeks only to analyze policy documents themselves. While the concept of coherency has been analyzed in policy documents in relation in curricula or pedagogical lens, it has not been utilized thus far in analyzing the foundational assumptions present in policy documents as they relate to epistemological claims and axiological objectives.

The primary methodology used was content analysis, although the final analysis was extended by a philosophical analytic approach influenced by Alain Badiou, a contemporary French philosopher whose interest in mathematics and education is timely and thought provoking. Badiou's methodology approach to studying policy both compliments and extends content analysis as I explain in detail in the last section of Chapter 4 and in the methods section of Chapter 5. The unique contribution of this dissertation was to extend the research field in mathematics education policy analysis beyond quantitative/qualitative methodologies, in order to incorporate a philosophical framework often overlooked, yet inherently present in policy discourses. The presupposition behind utilizing this framework is that mathematics must be contextualized at a philosophical level to better understand the connection between the transmission of valued mathematical knowledge and normative societal assumptions that are either reflected or perpetuated by the education of mathematics. Such normative assumptions can be studied through a systematic analysis of policy documents (Cross, 2004; Ozga, 2004).

My theoretical lens was taken from an extensive study of Alain Badiou's philosophical work. This lens allowed me to connect how ontological assumptions in policies relate to normative values our society places on mathematics. Badiou's revolutionary ideas enabled me to critique critical theories in mathematics education and envision new alternatives to invigorate a philosophical praxis in the public school mathematics classroom. This dissertation study is grounded by a conviction, influenced by Badiou, that the philosophical discussions of 19th century and early 20th century centering on ontological questions ought to play a role in sound pedagogical theory in mathematics education (Cobb et al, 1992; Radford, 2006; Warnick & Stemhagen, 2007). Perhaps, even more radical, is the conviction I share with Badiou that mathematics as it was practiced and revered in Ancient Greece ought to be considered in modern theoretical work in philosophy of mathematics education.

Throughout this study, Badiou's maxim that "ontology is mathematics" plays a key role. I took seriously Badiou's claim that ontology, the study of being, has been unjustly overlooked in contemporary philosophy, and must be revived in order for authentic social justice transformative change to occur. In addition, I believe Badiou's philosophical work has a particularly important place in theorizing educational practices today, especially in mathematics, which is ontological in nature according to Badiou. Badiou contends that philosophy has gone astray in the last several decades and part of his project is to reconnect the ancient way of philosophical inquiry with the modern analytic and continental traditions. He explains that although philosophy itself can never uncover any truths, it is nonetheless essential for understanding truths when they do arise.

Inspired by Badiou, I began this dissertation by first investigating the history of philosophy of mathematics as well as a review of the conditions that govern the "state of the situation" as it stands in today's U.S. education policy landscape. Connecting this work with the methodology of content analysis, which has a long history of being used to study policy discourse, I created distinctive analytic constructs, which were used extensively in the coding process. I also incorporate Badiou's methodology of set theory, which is a branch of modern mathematics that studies sets of objects such as numbers or concepts, as a supplement methodology. While the bulk of the empirical work of this study is content analysis, Badiou's use of set theory serves as an experimental method that helps me see connections between codes and documents that I normally would miss. Theoretical grounding was made using Badiou's discussion of "subject of truths" and "events"; these concepts help me envision the role of professional teachers who work in the complex, often tense, world of mathematics education. It is my contention, following Badiou, that expert knowledge of the "state of the situation", which is a conceptual way of thinking about a particular political, cultural, and historical context, is beneficial for teachers and theorists working in public education today. More specifically for this study, understanding the "state of the situation" in national education policy centering around mathematics, can help teachers implement curricula and pedagogical practices, and can help theorists better analyze the way in which these practices align or do not align such that they are coherent within the discourse itself and with one another.

1.2. Significance to the field

There has been a plethora of scholarship investigating policy reform packages and the discourse that surrounds them (e.g. Charalambous & Phillippou, 2010; Dejarnette, 2012; Schmidt, 2012). The research can be categorized by two broad agendas: social justice pursuits in order to understand how minority groups can be included in the "STEM pipeline" and pragmatic efforts to ensure school districts and communities have the necessary resources to implement STEM reforms. These distinctive research agendas are indeed important for ameliorative efforts to enhance both individual and national objectives; however, these research agendas are not nearly exhaustive enough to provide useful information for policy makers and educations of mathematics education in the U.S.

Education policy research is a widespread area of study, especially given the current trends in evaluation, assessment, and efficiency. Due to these trends, most policy research is conducted as "*research for*" policy not "*research of*" policy (italics added, Cross, 2004). *Research for* policy can have the following objectives: 1. To study a specific policy implementation process to assess its effectiveness (e.g. Honig, 2006) or 2. To employ experimental or observational methods for the purpose of recommending specific policy interventions (e.g. Kilpatrick, 2001; Radford, 2006). While these are worthy research agendas, certain assumptions about mathematics are often left uncontested. However, it is precisely these disregarded assumptions that are foundational to epistemological claims that underlie pedagogical theories on learning and axiological objectives that specify what mathematics education ought to be used for. This connection between ontological assumptions about what mathematical objects are, epistemological claims on teaching and learning, and axiological objectives as to what the mathematics education should be used for is discussed in great detail in Chapter 3. It is suffix here to say that such connections ought to be studied and that they exist nevertheless educators, policy makers, and theorists call attention to them.

Research of policy seeks to understand the explicit and implicit messages embedded within policy documents, in order to enhance, by way of critique, the overall objectives of education policy. This meta-level of analysis is extremely important today due to the complexity and multiple contexts in which education in the U.S is situated. Policy, after all, is neither a static entity nor a controlled unmediated practice. Rather it is a process that is struggled over by many different stakeholders at all levels of development and implementation. Ozga (2004) argued that *research of* policy is an undeveloped field of research, and urges educational researchers to develop rigorous methodological and interdisciplinary approaches for analyzing policy. Concurring with Ozga, Cross (2004) defines *research of* policy as a critique of policy itself insofar as such research is a vital component of the scholarly work needed in a democratic state. He argues that research of policy contributed to the protection of our fragile democratic state by increasing the public awareness of government activities. Moreover, research of policy enables a reflexivity to emerge that allows researchers to ask more complex questions about the purposes of education, and how such purposes can be attained comprehensively through policy initiatives. Again, the relationship between assumptions about mathematics (ontology), claims on best practices of teaching mathematics (epistemology), and aims of policy reforms (axiology), all relate to one another and ought to be investigated for how this relationship is discussed and presented in public policy texts.

Several scholars have engaged in *research of* mathematics policy. For example, theoretical gaps in mathematics pedagogical practices as advocated by the National Council of Teachers of Mathematics' (NCTM) Standards and Principles has also been critiqued rigorously through multiple lenses, including examining class, cognition, and race issues (Apple, 1992; Kelly, 2008; Martin, 2003). Some critical theorists and researchers argue that mathematics education policy has been simplified and appropriated to only serve neo-liberal economic objectives, which for them are anti-democratic and lead to furthering the social inequities prevalent in U.S. society (see, for instance, Frankenstein, 1984; Gutstein, 2008; Skovsmose, 1994).

While the aforementioned work is vital to ensuring a strong democracy and a strong educational system, it ignores philosophical assumptions about the field of mathematics itself, and fails to name the ontological commitments a given pedagogical practice upholds. Rightfully, researchers have focused on epistemological inquiry of mathematics education; however, ontology inquiry is crucial since it unveils the contingent assumptions behind epistemological stances. This lack of research is peculiar, since mathematics is a human field of study that attempts to explain, through a rigorously deductive model the existing components of reality and the structures, patterns, and relations such a reality consists of.

A philosophical perspective is lacking in educational research today, particularly when it comes to *research of* policy. Philosophically oriented scholars of education have asserted that all educational research assumes philosophical commitments (Biesta, 2010; Bridges & Smith, 2007; Holma, 2010; Phillips, 2007). While work has been done utilizing a philosophical perspective in mathematics education scholarship, very little has discussed ontology and even less has analyzed education policy. Ontological inquiry in education is slowly gaining momentum (e.g. Brown, 2010; Cobb et al. 1992, Restivo, Bendegam, & Fischer, 1993). Yet, with the exception of a few scholars (e.g. Bosse, 2006), very little work has analyzed policy specifically for its ontological commitments.

This dissertation fills the gap in educational *research of* policy by inserting a philosophical perspective to analyze mathematics education policy. By questioning the underlying conceptualization of mathematics itself, its ontological assumptions, research of policy can provide a rich descriptive model of mathematics education policy. Such a model provides a more comprehensive framework to critique reform policies as well as suggest alternate ones. By incorporating a philosophical theoretical framework for investigating the ontological assumptions mathematics education can posit about the very nature of mathematics, researchers and theorists may be able to ask more complex questions about the way in which mathematics, as a discipline and as a school subject, can influence societal normative values and the political educational goals that adopt them. In addition, the investigation of policy texts using a philosophical lens opens up a space for potentially new visions of how philosophy of mathematics education can play a role in policy discourses and how educators can enact real change in their own classrooms while navigating the education policy landscape that governs how and why they teach mathematics.

To summarize, this dissertation aims to analyze for policy coherency (aims - axiological, pedagogies- epistemological, and assumptions – ontological, in policy discourse), to explore what are the ontological assumptions present in policy documents and to provide useful information for policymakers, educators, and researches

1.2.1. Research Questions

1. What ontological conceptions of mathematics are embedded in U.S. educational policy reform initiatives?

2. To what extent are the ontological conceptions of mathematics coherent with pedagogical and educational objectives of the policies?
3. What potential implications for mathematics education does understanding these relationships provide to the teacher and to the students in the classroom?

1.3. Overview

The following chapter, Chapter 2, provides a review of the pertinent literature surrounding mathematics education reform in the U.S. I begin by explaining what policy reforms mean and how historically they have been conceived. Next, I give a general linear account of the major U.S. policy reforms in mathematics. After this, I delve into the literature that critiques specific reforms and I interpret how such critiques fit within my project here. Last, I give a short philosophical analysis of some of the work that has been critiquing the way numbers have been used to justify policy reform efforts. This is another way to view mathematics' place in education. Mathematics is both a subject of reform as well as a means to justify and assess the effectiveness of reforms. This is an interesting duality that no other school subject has and therefore I feel it necessary to discuss it here.

Chapter 3 provides a review of the philosophy literature as it pertains to this dissertation study. My objective here is to provide the reader with important background information about the field of philosophy of mathematics so that he/she could make sense of the subsequent chapter on Alain Badiou, who is a contemporary philosopher whose unique contribution in the field of philosophy, education, and mathematics, among others, cannot be fully appreciated without a sense of the philosophical discursive tradition on ontology. This chapter is spilt into two parts. The first part of the chapter explores how the relationship between philosophy, mathematics, and education ought to be conceptualized. Through exploring the literature on philosophy of education and philosophy of mathematics, I conclude with a final relationship that I believe would best be suited for the philosophical policy analysis I attempted to accomplish in this study. The second part of Chapter 3 discusses what will serve as the analytic constructs of my study. Before I can utilize these philosophical categories in my content analysis methodology, however, I first need to show why they are essential ways of thinking about the components of mathematics policy documents. I believe this chapter does so and sets the stage for the reader to understand why I coded the things I did and how I eventually made sense of these codes to answer my research questions.

Chapter 4 is the most unique and richly philosophical part of this dissertation. It is here that I extrapolate Alain Badiou's philosophy and explain how it is relevant to my study. In this theoretical chapter, I discuss Badiou's work as it relates to critiquing societal norms and potentials for revolutionary change. I also describe how I utilize Badiou's philosophical method for the analysis of my own data.

Chapter 5 provides the background on the methodology I used for this dissertation. Various examples of content analysis studies are outlined and the principles and techniques of content analysis are explained in the beginning section of this chapter. Then, I describe how the methodology was used in this dissertation study. I provide a detailed description of the data gathering method and coding procedure. Last, I explain my use of mathematical set theory as a methodology for the last analysis of my data.

Badiou's work in set theory is interested in understanding the "state of the situation" for envisioning where political revolutionary change can occur, while my use of set theory is interested in understanding the coherency or lack thereof of mathematics policy; therefore my "state of the situation" is comparatively smaller, yet nonetheless as meaningful for revolutionary change.

Chapter 6 presents the findings through both visual aids and descriptive writing. It is separated into sections that progress from the most general findings to specific ones. First I explain the distribution of the coding categories as they appeared in the policy documents. Next, I show how the codes related to one another within the same documents. Then, I present the quantitative findings that showed which words or phrases appeared most in the documents. I provide examples and commentary of these findings. Last, I attempt the new methodology of set theory and learn more about how the codes were presented and represented in the documents.

Chapter 7 discusses and provides context for the results of the study. Here, I attempt to answer the research questions. In order to do this, I first provide a clearer picture of the policy documents as they relate to the three larger philosophical categories of axiology, epistemology, and ontology. Then, I turn to the research questions specifically and reflect on what I have learned.

Chapter 8, the concluding chapter, revisits the reform policies through a Badiouian lens and asks what implications the findings of this dissertation have for mathematics education in the U.S., and offers some suggestions and guidelines for educational researchers, educators, and theorists.

Chapter 2: Review of the Policy Literature

In this chapter I present a literature review that discusses policy reforms efforts in mathematics education in the United States. I begin by offering a perspective of how to understand the mission of the majority of national education policies and the discourses that surround them. Next, I provide a synopsis of the reforms in mathematics education over the last few decades. Last, I elaborate on several ways in which policies have been critiqued in policy and how such critiques have influenced the work done in this dissertation. This last section gives concrete examples of the work that Ozga (2004) and Cross (2004) advocate. Subsequently, I believe it is imperative researchers of policy understand the historical linear progression of education policies, in all their complexity and philosophical assumptions, before, during, and after they offer critique and alternatives to education. It is towards these ends that this chapter written.

2.1. Educational Policy

Policy generally refers to a political activity supported by a governmental body for the purposes of regulation, revising, and changing social needs. “Social Policy” is defined as referring “to the principles that govern action directed towards given ends. The concept denotes action about means as well as ends and it, therefore, implies change: changing situations, systems, practices, behaviours” (Titmuss, 1974, p. 138). In education, policy often refers to the way in which governmental bodies stipulate the rules and regulations school districts ought to adhere to. Policy discourse is a “complex entity that extends into the realms of ideology, strategy, language *and* practice, and is shaped by the relations between power and knowledge” (Sharp & Richardson, 2001, p.195). Simply put, policy discourse institutionalizes a way of thinking that governs state policy rhetoric and practice, but which also has profound implications for how citizens behave.

In *Policy Paradox*, Stone (2002) explains that there are five justifications that dominate the language of policy discourse:

1. Equity (everyone gets treated alike)
2. Efficiency (getting the most output for a given input)
3. Security (satisfaction of minimum human needs)
4. Liberty (do as you wish without hurting others)
5. Community (people do not live in a vacuum but amongst others) (p. 37).

In education policy discourse, these five justifications can be observed. In President Bush's signature education reform act, *No Child Left Behind*, the word "all" was used incessantly; this signals the language of equity since children through the U.S. were considered one unified group that ought to be treated the same and be provided with the same educational resources. The justification of equity can be read in many current education policies, especially in the STEM initiative. In the findings chapter, I provide many examples of this and link it to the axiological objective of democracy and utilitarian workforce.

An especially cogent example of another justification in policy language can be found in President Obama's speech to American school children on September 9th, 2009:

> We need every single one of you to develop your talents, skills and intellect so you can help solve our most difficult problems. If you don't do that - if you quit on school - you're not just quitting on yourself, you're quitting on your country [1](para 14).

[1] http://www.huffingtonpost.com/2009/09/07/obama-speech-to-schoolchi_n_278763.html

Here Obama was touching on the justification of security and community. The message is that if children do not "develop their talents" our country as we know it will be in trouble. The community begins with oneself, and then goes to the school, which encompasses district neighborhood boundaries, and then moves directly to the country as a whole. Some other justifications can be found in the *Race to the Top* education initiative:

> …a new vision for a 21st century education — one where we aren't just supporting existing schools, but spurring innovation; where we're not just investing more money, but demanding more reform; where parents take responsibility for their children's success; where our schools and government are accountable for results; where we're recruiting, retaining, and rewarding an army of new teachers, and students are excited to learn because they're attending schools of the future; and where we expect all our children not only to graduate high school, but to graduate college and get a good paying job (Obama, 2007, p. 31).

The above quote depicts the justification of equality, liberty, and efficiency. Since President Bush's *No Child Left Behind* education reform platform, "equity" meant giving all children equal services and assessing if all students can meet certain specified educational benchmarks for success in learning. The justification of efficiency is also evident here, although it has become even more important recently with the emphasis on "best practice" research methods and "what works" educational networks. Liberty is also implicitly present in the above two quotes since the emphasis is on individuals and their own educational opportunities, which are not seen as interrelated to larger socioeconomic and cultural domains. Another justification that Stone (2002) did not mention, but is

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First Posted: 09- 7-09 12:42 PM | Updated: 10-23-09 05:12 AM retrieved 4/29/11 obvious in current reform discourses is that of responsibility. Once the administration creates education policies it sees as just and equitable and oversees the implementation process, it is solely up to the individual students to take advantage of their own educational opportunities. As many critical education researchers and theorists point out (e.g. Apple, 1992; Gabbard, 2000; Martin, 2003) this is problematic for several reasons, since national policy officials seem to wash their hands clean of the large disparities in social economic status that have been shown to be much greater influences on educational success than top-down reforms made by the government. Before I can go further with a critique of mathematics education policy, I think it is worthwhile to know the history of the reforms and the context out of which they arose. The next two sections of this chapter provide the history and context, which enables a more meaningful understanding of today's U.S. policies in mathematics education

2.2. History of U.S. Reform Policies in Mathematics

The national interest in mathematics education at the policy level dates back at least to the 1957 Russian Sputnik Launch and more distinctly to the release of *A Nation at Risk* (Woodward, 2004). On both these occasions, mathematics education was identified as centrally important for maintaining a national competitive edge in a globally changing world. The concern about mathematics education intensified in the 1990s when the TIMSS (Third International Mathematics and Science Study) study depicted United States students as mediocre in mathematics compared to their international counterparts. Over the decades, various large-scale policy initiatives have surfaced, attempting widespread reform efforts in mathematics education.

In the 1920's the Progressive Movement, influenced by philosophers of education such as John Dewey called for "schools of tomorrow" where students would be engaged in meaningful and authentic learning experiences of their own choosing and would be active in constructing their own knowledge. Such swings in the pendulum of progressive mathematics reform are the norm rather than the outlier in policy movements. During John Dewey's era education was heavily influenced by a child-centered approach to learning. Later, a group of philosophers of mathematics and mathematicians envisioned a new reform, termed "New Math," which rationalized that students needed a strong conceptual understanding of number theory before they learned traditional algorithms and computation procedures. "New Math" was the term used for pedagogical alternatives that attempted to provide the learner a holistic abstract understanding of mathematics. An example of this approach is the "New Math" reform in the 1960s and the Bourbaki movement in Europe, both of which did not succeed in the educational sense (Ralston, 2004). This reform did not last long in the U.S. due in part to a strong backlash from parents claiming that their children could not learn the mathematics being taught in school and further that it had no utilitarian purpose in finding a job. This type of reform failed for conflicting reasons; many proclaimed it to be too elitist, leaving a generation of mathematics students disinterested at best and antagonistic at worst about the subject of mathematics (Restivo, Bendegam, & Fischer, 1993).

Later, the "Back to Basics" movement called for a return to the authoritative mathematics teacher who was entrusted to make sure his students learns the basic traditional algorithms in mathematics. Again, there were many critiques since students were thought to not thoroughly understand the mathematical procedures they were doing nor was problem solving being stressed a key mathematical activity for ensuring job security (Klein, 2003).

Reforms in the U.S were most contentious in the 1990's and explicitly became more considered with competition, both individually in the job market and nationally at the global economic world stage (Klein, 2003). The first mention we have of the axiological claim that links mathematics education to global competitive economy begins in the policy documents during this decade. Several documents are extremely clear in this rhetoric. In a document titled "The State of Mathematics Education: Building a Strong Foundation for 21st Century", Mr. Riley, the Secretary of the Department of Education, wrote "It should come as no surprise then that almost 90 percent of new jobs require more than a high school level of literacy and math skills…indeed, almost every job today increasingly demands a combination of theoretical knowledge and skills that require learning throughout a lifetime" (1998, p. 487). The method he proposes to accomplish this lofty goal is through strengthening the education of math and science, especially in elementary grades, increasing the amount of teachers with substantive background in these fields, and influencing minority groups to pursue STEM careers in higher education. Riley acknowledged that our society is based upon technology, which is itself based on mathematics and science. For him, as with many other policymakers, this fact leads to the urgency of promoting and improving the education within these crucial subjects, again with an emphasis on competition and remaining the leading technological country in the world.

In another document, titled “Improving math and science teaching to be first in the world in science and mathematics” (McKinney, 1992), Fuhrman, director of the Consortium for Policy Research in Education at Rutgers University is quoted as saying:

> Developing such integrated policies that actually relate to one another, not just at the same time, but on parallel tracks, is far different from developing the kind of education policies we have had in the past… in a political system used to grinding out discrete, un-integrated, often contradictory fragmented policies, policies that bring credit to the author and are distinguished from whatever was there previously, We certainly don’t want that to happen to these new reform efforts where a true effort has been made to create policies that link together (p. 4).

Fuhrman continues to make strong epistemological and ontological claims: she asserts that "all children must be given the opportunity to learn mathematics and science…our education system offers minimum math to most, algebra to some, and calculus to only a few…a serious mismatch exists between what our students are capable of learning and what they are taught…” (p. 5). To combat this problem, Fuhrman suggests laying out a detailed framework for teaching mathematics and science starting in kindergarten and increasing the basic understanding of math and science to all elementary school teachers. Moreover, she believes we must teach mathematics and science through hands on real life experiences, that there is more than one way to solve a problem, and that we should encourage students to explore and to be curious. By advocating for constructivist pedagogies, Fuhrman exemplifies the tension in the 1990’s between past traditional epistemological approaches to teaching and learning mathematics, and progressive theories that seem to be founded on a radically different ontological view of mathematics and, far from the Platonist view about numbers as static unchangeable entities held unquestioned at least in the public’s subconscious for so long.

The eruption of constructivist discourse in policy was fervently disputed. In, January 1998, U.S. Secretary of Education Richard Riley called for an end to the “math wars” however the exact opposite of Riley’s intentions actually occurred. Seven Nobel Laureates and winners of field medals wrote an “open letter to Secretary Riley” expressing their disagreement with the way in which mathematics education reforms were taking place. (Appendix D.1). They were upset with the drastic switches in mathematics education and deeply concerned with the unfounded claims about what mathematics is and how best to teach it that were implicit in the policies. Higher education institutions that had teacher education programs have a direct and powerful influence on elementary and middle school teachers (Klein, 2003).

At the end of the 20th century, mathematics education policies in U.S. public schools were in a state of flux. Disagreements between parents and mathematicians on one hand, and professional educators, on the other, continued without clear resolution. Parents, for the most part, have also been silent, trusting the experts, the teachers' organizations and math educators. Several reform curricula do not provide textbooks in the usual sense, and this deprives parents of one important source of information. Yet, among parents, attitudes may also be changing, especially since newer reforms in 2000’s called for giving parents more school choice.

Perhaps one of the largest influences on mathematics education reform has been the National Council of Teachers of Mathematics (NCTM), the first national organization of professionals and the first in the nation to come up with a common curriculum for mathematics. This was revised several times and influenced the Common Core movement, which aims at establishing a common mathematics curriculum nationwide. The Common Core State Standards (CCSS) originally began as an initiative that was a join effort by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) in partnership with Achieve, ACT and the College Board (Klein, 2003). Currently, they are adopted by forty-seven states and part of the Race to the Top initiative.

Current U.S. educational policy on mathematics is layered with conflicting messages. On one hand, NCTM advocates for social constructivist approaches to learning, yet it also advocates for technological expertise needed to ensure U.S. global success. In addition, *21st Century Taskforce*, a federally sponsored group, advocates for cooperative learning and creative thinking, yet it situates this agenda within capitalistic incentives for maintaining dominance over world markets. On the other hand, the predominant discourse in federal legislation and policy briefings name competition and workforce skills as the most important characteristics of mathematics reform, yet also proclaim the importance of providing quality education to minorities and low-income students (e.g. Apple, 1992; Gabbard, 2000; Martin, 2003).

2.3. The STEM Policy

The STEM acronym stands for the importance science, technology, engineering, and mathematics ought to play in the educational reform policies. "STEM" began as "SMET," standing for science, mathematics, engineering, and technology. In the 1990's the National Science Foundation (NSF) coined this term in order to emphasize the importance of these four distinct disciplines (Sanders, 2010). The acronym was changed to “STEM” to help promote it, yet there are still a considerable amount of Americans that still associate STEM with stem cell research. This is problematic since parents ought to be made fully aware of the kinds of reforms their children will be affected by. Even many educators are unclear about what STEM education is. The National Science Foundation explains that STEM education is about proliferating the importance of these four disciplines in the education community and society at large. The acronym is ambiguous, since educators have also used it to describe the inherent interconnectedness between the four disciplines, as well as create curricula and pedagogy that links them together within one year or classroom. Below are several possible ways to understand the STEM reform initiative:

- Science, mathematics, engineering, and technology are fields in which the U.S. needs to produce more highly competent workers in order to compete in the future global marketplace.
- Science, mathematics, engineering, and technology are inherently linked and therefore it would be advantageous for the learner to have real-life hands-on projects that explain and utilize the interconnectedness of them.
- A high level of understanding of the fields of science, mathematics, technology, and engineering are essential knowledge sources for all future democratic citizens, and especially so for minority and under-represented groups that may not have had access to this important area of knowledge, and this has hampered not only their ability to find a fulfilling job, but also to function as effective

citizens (e.g. get a loan, understanding the voting process, manage their credit and money) (Brown et. al. 2011; Bybee, 2010).

Perhaps the argument can be made that the three objectives listed above are one and the same, or at the very least compliment each other. As will be apparent in the empirical section of this dissertation, these three axiological aims are prevalent in all mathematics policy reform documents; not only do these three objectives occur relatively equally in the discourse, they occur simultaneously in any given document. After all, being a high functioning democratic citizen may also mean having a fulfilling job. Further, generating citizens that increasingly go into technologically skilled jobs helps the nation compete in economic global market. Additionally, understanding the interconnectedness of science, mathematics, technology, and engineering may improve the teaching and learning of these traditionally difficult subjects and therefore enhance the objective of obtaining a high level of literacy in them, which in turn helps you get a job and be a good citizen. All of this is speculation since there is no way for me to clearly gauge what the motives of policymakers are and exactly how the rhetoric found in policy documents matches the varying but unified axiological objectives education of mathematics. What I must stress here is that policy discourse is inherently concerned with axiological objectives; therefore it is logical to assume at the onset of this dissertation study that axiological objectives would be the most prevalent code found in the analysis. Regardless of this tautology, policy documents are more than simply axiological objectives about the purposes of mathematics education. As I explained in the introduction, what I am concerned about in this study is examining how the axiological objectives present in policies about mathematics interact with the other discourses present in policy documents, such as the epistemological claims that specify what pedagogical practices are best for teaching and learning of mathematics, and ontological assumptions that hint at the conception of mathematics that fundamentally shapes the way mathematics is thought about and used in education. Indeed, there are several presuppositions internal to these educational objectives, such as what mathematics ought to be used for, how mathematics shapes the modern world, and the universal quality of mathematical concepts. The conviction underlying this dissertation is that these presuppositions must be rigorously investigated, not only to aid in implementation and conceptualization of sound cogent policy reforms in mathematics education, but also in reflecting on the societal implications such reform efforts signify.

Generally, the STEM initiative has two main interconnecting objectives at the macro and micro level. At the national macro level, mathematics education is centrally important as a pillar for cementing the epistemological and pragmatic advances in technology and engineering that our country needs in order to stay economically competitive on a global level. At the micro level, the objective is for individual mathematics students to have a strong understanding of the interdisciplinary link, objectives, and techniques that categorize STEM curricula, in order for them to become critical literate citizens and procure a rewarding financially secure employment in their adult lives (e.g. Brown et al., 2011; Bybee, 2010).

Since the term STEM was first coined in 1990 by the National Science Foundation, there has been a plethora of scholarship investigating curricula and implementation strategies. The research can be categorized by two broad agendas: social justice aims that investigate how minority groups can be better represented in the “STEM pipeline” (e.g. George et al., 2001), and pragmatic efforts to ensure school districts and communities have the necessary resources to implement STEM reforms (e.g. Kuenzi, Matthews, & Mangan, 2006). These parallel research agendas are indeed important for both the individual and national objectives, however they are not exhaustive ways. Creating exemplary curricula reforms in mathematics education must be anchored by coherent assumptions, which are always either explicitly and implicitly embedded in the reform discourses about what mathematics is, how it can be taught, and for what purposes its knowledge should be used. These assumptions are philosophical in nature and ought to be researched within an interdisciplinary research methodology that incorporates philosophical constructs from ontology, epistemology, and axiology.

2.4. Education Policy Critiques

Education policy critiques encompass large interrelated areas. Many critiques center on exploring the efficiency of the specific policies; others concentrate on uncovering the fallible foundational principles that are used to justify policy decisions. Still others question the covert agendas behind policies, which either intentionally or unintentionally negatively affect minority groups. In this section I highlight examples of each type and explain how these critiques have influenced my own research in mathematics education policy.

Let me begin by explaining critiques on policies’ effectiveness to enact the reform changes. Critiques on policies’ effectiveness question whether the policies, as they are stated, cannot reach their stated goal. Some scholars have argued that there have only been cosmetic changes in mathematics education with no real changes taking place. Reys (2001) asserts that the reason for lack of change in reforms is the difficulty in changing textbooks, which are still the primary teaching tool in schools. Districts that are undergoing financial stress do not have the funds necessary for getting new resources to complement the guidelines certain policies specify. Without the funding, policies become purely rhetorical and have little or no effect on the real day-to-day lives of teachers and students in the classroom (Apple, 2003). Schoenfeld (2004) claims that the NCTM and National Science Foundation (NSF) policy standards recommendations have been vague and backed by little or no evidence or research. This is an example of critiques on efficiency that are quite widespread on all ends of the educational debate. The commonality between these critiques of educational policy is that they all expose the problems with the way policies specify how changes will take place.

Berry, Ellis, & Mark (2005) argue that the "reforms" in mathematics education were merely revisions, since they do not qualify as true paradigm shifts in conceptions of knowledge. These reforms, it is argued, do not offer a radically different conception of knowledge, nor do they provide an essentially different pedagogical approach that would benefit the historically marginalized population of students that oftentimes do not gain access to higher-level mathematics knowledge. While this critique on policy can be categorized as questioning the effectiveness of policies to reach their goals, it also can be an example of critiques that question the foundational views inherent in policy.

Foundational views could encompass cultural, social, political, and philosophical perspectives. Stigler and Hiebert (2004) express the idea that “implementation cannot be successful unless it is accompanied by ideological and cultural change within schools” (p. 15). What these authors are addressing is the way in which mathematics education is related to our cultural perceptions about the uses and values mathematics has in our society. For example, if educators and policymakers believe mathematics is a necessary tool for economic prosperity for individual and national gains, they will emphasis the utilitarian aspects of mathematics and may ignore the beauty of mathematical proofs and procedures, not to mention the creative and imaginative disposition needed to enjoy and be good at mathematics. Further, if educators and policy makers have not experienced the joy a mathematician feels when attempting to solve a problem, they may not emphasis this kind of aesthetic experience when doing mathematics. Hence, educators and policymakers that either do not appreciate the wonder of mathematics or see it as a means to an economic ends, will interpreted and implement policies to reform mathematics education in perhaps different ways than originally intended by the theorists and researchers that have helped shape such reforms.

Mathematics education has undergone many reforms as discussed earlier. Much of the critiques of the reforms center around not the axiological objectives the reforms were explicitly said to serve, but on the grounds of epistemological concerns as to what knowledge was been disseminated and how. A popular slogan depicting mathematics reform efforts is the statement that they have been “a mile high and an inch deep” (Davison & Mitchell, 2008, p. 150). This translates as a critique on the content and scope of the U.S. mathematics curriculum such that that there is too much unrelated content that is presented in a superficial or disjointed way to students. Bolden and Newton (2008) studied the policy reforms in the UK. They concluded that teachers' epistemological beliefs influence the way policies are interpreted in the primary mathematics classroom and call for researchers to be more cognizant of teachers' worldviews as they relate to their conceptual understanding of mathematics.

Also concerned with investigating fundamental issues, Spillane (2000) analyzed policy through a cognitive lens in order to understand the district's role in the implementation process. Spillane writes:

> In conventional views, policy is often portrayed as a stimulus and the choices facing implementers concern whether to change their existing behavior and implement the policy, ignore it, or work at sabotaging or circumventing it. Policy and the policy message are taken as givens. An array of factors influences implementation. Ambiguous, unclear, and inconsistent policies that lack authority maximize enactors' discretion with respect to implementation. (p. 144-145).

Spillane is arguing that policies are only as good as their implementation strategies. Policies that ignore socioeconomic factors, which greatly influence school districts ability to be successful, as well as policies that do not take into account teachers and supervisors daily activities and understanding of policy agendas are destine to fail according to Spillane. Consequently, in order for policies to have a chance for successful implementation, teachers must play a more essential role. This is not done by simply assessing their effectiveness in meeting policy guidelines, but in allowing them to have a more direct and powerful role in making policy decisions. One way to begin to do that is to provide teachers the necessary tools by which they can understand policy discourses and have a means by which they can critique and offer improvements to them. This brings me to the question of how to understand policies, which was the major influence guiding my work here.

There are so many conflicting policy critiques that it is difficult to make judgments about which policies make sense and which do not. A useful strategy is to ask what are the major components of policy and how do these components relate to each other. If they relate well, then it is possible to say that a given policy can be effective in meeting its goal. If the components in a policy do not mesh well together, i.e. there are contradictions in stated goals or how to meet them, then it is likely that the stated policy will not meet its objective. One lens by which this can be done is to critique the "coherence" of policies. The concept of coherence has guided the empirical work in this dissertation. A particular type of coherence is alignment, which asks by what degree do various policy instruments available to the system, e.g. standards, textbooks, and assessments, accord with each other and with school practice (Smith and O'Day 1993). Another definition of coherence focuses on school organization and does so by assessing how policies articulate a unified vision for school reform such that there is a common set of values and beliefs that are fostered and realized school wide (Coleman et. al., 1982; Newmann et al., 2001). An example of research that asks if policies are coherent is Schmidt, Wang, and McKnight (2005). These researchers ask how comparable U.S content standards are with other TIMSS countries and do the U.S. standards reflect a coherent framework. The researchers focused on the TIMSS study, which depicted the U.S. math and science curriculum to be unfocused, repetitive, and to be undemanding by international standards (Schmidt, Houang, & Cogan, 2001). They defined content standards to be coherent “if they are articulated over time as a sequence of topics and performances consistent with the logical and if appropriate hierarchical nature of the disciplinary connect from which the subject matter derives” (p. 9).

Schmidt, Houang, & Cogan (2001) using the definition of coherency stated above, found that the U.S. standards are in fact not coherent. This is significant for mathematics educators and policymakers for obvious reasons and ought to affect the trajectory of policy decisions. Indeed, with the new Common Core mathematics standards and the Race to the Top Initiative that allocates funding based on each state’s compliance with using the Common Core standards, such changes may have already taken place. My concern is will this lesson be enough to meet the objective of providing excellent mathematics instruction in the U.S.? While I applaud the efforts in uncovering coherence in curriculum standards, I wonder why that same question has not been made in asking whether policies themselves are coherent. After all, curriculum is an important part of policy decisions, but not the only, nor the more dominant aspect of policy discourses. Education policies articulate and help shape normative claims about what mathematics education ought to serve. Moreover, education policies specify what knowledge is most useful and how best it should be taught. These are axiological and epistemological claims. How these claims interact with ontological assumptions about what is mathematics and how it even can be used or understood is an important question. This is a meta-question about coherence that calls for philosophical inquiry to ground it at both ends. On the ontological end, coherence can be studied by exploring the connection between how mathematics is conceptualized in the classroom and how students come to learn it best. On the axiological end, coherence can be studied by relating the political agendas of policy with the day-to-day real life activities of a teacher and his students.

There are other ways to understand the fundamental aspects of policy reforms in addition to the ones mentioned above. I turn to a philosophical lens that questions the fundamental philosophical assumptions latent in policy discourses. First, let us question the term the U.S. government currently calls the “the gold standard” in policy research, which means research conducted in an experimental quantitative approach (Lester, 2005). Policies that have these kinds of research justification are thought to be more effective in reaching their goals than others. On the other hand, many educational researchers are calling this expectation of quality research as far from quality and even biased against truly understanding the educational field and helping to fix it. The following quote is exemplar of many educational theorists and researchers argument over the “gold standard”

> Many thoughtful people are critical of the quality of research in mathematics education. They look at tables of statistical data and they say "So what!" They feel that vital questions go unanswered while means, standard deviations, and t-tests pile up (Lester, 2005).

In policy discourse, numbers are ubiquitous and used to make and justify decisions. However, counting, which precedes number classification, always has to do with inclusion and exclusion. “Every number is an assertion about similarities and differences. No number is innocent, for it is impossible to count without making judgments about categorization. Every number is a political claim about where to draw the line. And similarities and differences are the ultimate basis for decisions in public policy” (Davis, 1992, p 167). “Counting says a phenomenon is common, regular, and expected …counting moves an event from the singular to the plural. To count something is to identify it and give it clear boundaries" (ibid, 172). Therefore, numbers are used to make normative claims about what is average or acceptable in a reform package. Numbers are also used to tell stories about what is to be counted and therefore assessed as effective proof that a given policy is working or not. "Numbers by seeming to be so precise, help bolster the authority of those who count" (Stone, 2002, p. 176). However, counting is a phenomenon whether it is U.S. census or children's scores on a standardized test, which must always leave room for interpretation. People respond to being measured and act accordingly. In addition, what is measured and how is disputed. For instance, in the case of the TIMSS results, researchers have argued that the data does not justify the results made by policy officials (e.g. Schmidt, Wang, & McKnight, 2005).

The critique of quantitative methodology is even more poignant when applied to mathematics education, since it is mathematical theory that makes this research practice even possible. Further, it is the contentious understanding of the ontological questions fundamental to mathematics that underpins the way in which mathematical data is understood and therefore used to drive policy-making decisions. Numbers have a preeminent status in our scientific culture, as well as an overall omniscient societal value on everything around us, from our voting strategies to our health to our shopping habits. However, very few people have an in-depth understanding of mathematical theory and therefore have a misunderstanding of how numbers can and should be used to describe phenomena. One ontological view about numbers says, "Just as there are infinite ways of describing a single object in words or paint, so there are infinite ways of describing with numbers. Numbers are another form of poetry" (Davis, p. 163). Another way of conceptualizing numbers is that they are ambiguous symbols that work as metaphors to describe things that occur or can occur in our world. "Numbers make normative leaps and measures, which implies a need for action, because we do not measure things except when we want to change them or change our behavior in response in them" (Ibid, p. 167). Thus, the political tension of numbers usage in policy must not be ignored either by policy researchers or by educational professionals. Moreover, the way in which numbers are taught in class is intrinsically linked to the way numbers influence real lives of citizens and their children. A significant part of a teacher's role is to nurture future democratic citizens. Since mathematics plays a huge role in developing numerical literacy, a skill essential for the 21st century, the role of a teacher is threefold. One, she must ensure students develop a deep understanding of the discipline of mathematics. Two, she must provide and model critical approaches to mathematical discussions that shed light on the way numbers influence our lives and how we can be critical of how they are used and why. And three, she and her students must find a way in which to exercise praxis over the increasingly assessment and standardization movement that is inundating the mathematics public education classroom. Certainly, the second objective cannot be reached without the first since a deep understanding of the numbers (in the Common Core this is described as number sense and conceptual understanding) and the way in which they can be used precisely and effectively (in the Common Core this is described as computational and fluency with algorithms). Moreover, the third objective can only be superficially reached without a high degree of knowledge about how an ontological view of mathematics is latent in the standardization and assessment movement. Thus I can argue that the first and third objective cannot be reached without the second since a philosophical inquiry into numbers as they are used historically and culturally is necessary for building a deep understanding of mathematics as well as a way in which to critique the practices that mathematics is fundamentally a part of. Thus, an exemplary teacher must not only know a considerable amount of mathematical theory, but also possess an in-depth critical understanding of how mathematics has been discussed in policy. This mission has driven much of the work in this dissertation and speaks directly to Alain Badiou's contention that a political revolutionary must possess an expert knowledge of the "state of the situation", which can be translated as an in-depth knowledge of the overt political, social, and cultural contexts of any given sphere of our society, which in the case of this dissertation is U.S. mathematics education and its reform policies. Before utilizing this knowledge to help analyze policies, a better understand the philosophical categories that are central to mathematics and education is needed. This knowledge will aid the analysis, since as Badiou has explained, the "state of the situation" is not the truth of the situation but only shows what can exists in its representational form (i.e. how we can make sense of it).

Chapter 3: Review of the Philosophical Literature

This chapter reviews the philosophical literature that I have utilized in order to think through the way in which mathematics education policy reforms in the United States have functioned relate to the philosophies of mathematics education. In order to understand mathematics education reform policies it is useful to expand the inquiry into philosophical realms since this exploration will enable useful categories to emerge and relationships between discourses to become more apparent. These categories will be useful in the empirical part of this dissertation. The first part of this chapter focuses on establishing a relationship between philosophy, mathematics, and education. This relationship becomes guided by philosophical categories of axiology, epistemology, and ontology. The second half of this chapter delves deeper into these connections by extrapolating sub-categories within these intersections. These subcategories were used in the empirical analysis of the dissertation as analytic constructs.

3.1. Philosophy, Mathematics, and Education

Searching for a relationship between philosophy, mathematics, and education assumes that philosophy has a rightful place in mathematics education. This assumption is justified, not only for education in the broad sense, but particularly for mathematics, since the study of mathematics has been intertwined with philosophy proper dating back to ancient Greece. In Greece, mathematics was thought to be a necessary area of expertise preceding the study of philosophy. In the modern era, important figures in philosophy, such as Charles Peirce, have argued the intrinsic nature of mathematical thinking as being similar in kind to philosophical inquiry (Campos, 2010). Many of the great philosophers of the western philosophical tradition, such as Immanuel Kant, Baruch Spinoza, and Ludwig Wittgenstein, have made use of mathematics as an exemplar for understanding the limits of human knowledge.

Indeed, there is a separate philosophical field known as philosophy of mathematics, which studies among other things, the nature of numbers and the means by which humans come to understand mathematical concepts. During the late 19th century and early 20th century this branch of philosophy not only fostered newfound theories and debates in philosophy, but also helped create several important and quite useful fields in applied and pure mathematics, which generated new knowledge, set as set theory.

While the discipline of philosophy of mathematics has been pushed to the background in popular philosophical dialogue, the discipline of philosophy of education has continued to maintain its small yet important influence on educational discourse. This may be due to the fact that education, especially in the 21st century United States, has become highly visible to the public. However, with all the media coverage of public education, the dominant discourse is still predominantly concerned with direct means and ends of education, such as how best to implement a particular policy and which types of policies are most needed to impact the most good for the most amount of Americans (e.g. Apple 2003; Berry & Ellis, 2005; Gabbard, 2000). Thus, it seems that neither philosophy of mathematics nor philosophy of education has a direct impact on policy reform efforts. Nonetheless, these discourses have a significant role to play in critiquing reform efforts and offering alternative ones. This role can be further enhanced by providing a theoretical bridge between the discourses of philosophy of mathematics and philosophy of education to the education of mathematics.

There have been excellent efforts at conceptualizing the relationship between philosophy, education, and mathematics (Brown, 1995; Ernest, 2004; Steiner, 1987). The three disciplines of philosophy, education, and mathematics can certainly remain separate, and often do in their own respected inquires. However, as many disciplines have a way of dong, interdisciplinary links arise. These links can be very fruitful for each discipline involved and/or new branches of inquiry can emerge from their connections. Generally, there are three possible schemas:

- Philosophy of mathematics → as it relates to education
- Philosophy of education → as it relates to mathematics
- Practitioners of mathematics as their own views → relate to education.

The first schema has popular backing as this oft-cited quote could attest to: "All mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics" (Thom, 1973, p. 204). The presupposition behind this schema is that learning theories in education all rest on philosophical assumptions, although they can be bound by political agendas as well as social/cultural normative views. Here, epistemic as well as ontological assumptions are the fundamentals for thinking about the best teaching and learning theories for mathematics education. While I immediately gravitate towards this schema as a contender for my own convictions for research into mathematics education policy, I am unsure to what extent the philosophical categories of philosophy are used to research important issues in mathematics education policy; since the emphasis here is strictly on philosophy of mathematics as it relates to education, key axiological discourses might be overlooked.

The second schema anchors itself in political/ethical concerns in education, which are especially interesting when it comes to mathematics, but by doing this it can blind itself to other concerns, such as cognition of abstract knowledge and the aesthetic experience so often associated with learning mathematics (e.g. Crannell, 2009; Sinclair, 2001). In this schema, the emphasis is on the political and ethical issues in education and how these translate to the context of mathematics education. If we assume, as critical theorists do, that mathematics is a field inherent with explicit as well as implicit political agendas, it makes sense to assume a critical stance to its education and begin our critique within a philosophy of education perspective as it relates to mathematics education. Skovsmose (1994) in his book, *Towards a Critical Philosophy of Mathematics Education*, lays an excellent framework for thinking philosophically about the aims and means mathematics education ought to recognize and serve, which for him is always political in nature. Being a critical theorist, Skovsmose contends that power relations are inherent in mathematics and thus its education must serve the ethical and political dimensions of citizens who work towards a free and just democracy. While I believe his work is admirable, it lacks two components. First, it does not analyze current dominant trends in mathematics education, which makes implementation of his work strictly theoretical. Second, it assumes that only through teaching critical mathematics education can democratic ideals flourish, thus it completely disregards cognitive goals, which are also integral to citizenship in a modern technological democracy. Moreover, I am not convinced that exposing power relations will causally lead to a more just society as it simply replaces one form of hegemony or ideology with another. Rather, I contend that reorganizing our relationship with these power relations through ontological inquiries, which learning about mathematics itself helps us do, is a more successful way to reach democratic ideals.

Schema three is exemplified by studying the way in which mathematicians have historically contributed to the policies of mathematics education. The “Riley Letter,” published on November 18, 1999 in the Washington Post showcases this perspective (see Appendix D.1). The “Riley Letter”, written by mathematicians and scientist working in the field, expressed their discontent to the way in which mathematics was conceived and prescribed to by taught in current reforms. Specifically, they disagreed with NCTM’s (see Appendix D.2) rationale that children should be allowed to discover their own algorithms for math problems, rather than be taught to standard algorithm that has been approved for efficiency and greatest usefully in mathematics by the mathematical committee of our present society.

Taking a different perspective for schema three, we can become interested in the way in which the practice of working mathematicians and the communities in which they work are socially interactive. It is argued that within these consensual communities, much of the knowledge in mathematics is propagated through social and political avenues even if most mathematicians are unaware of this and claim objectivity of their discoveries (Restivo, Bendegam, & Fischer, 1993). Davis (1992) argues that a large percentage of mathematicians have been funded directly or indirectly by the federal government since

World War 2; it is this same government that also has a direct influence into what types of reform policies are made in education. Thus, we can see a clear link between federal policy in mathematics education and national security agendas.

We need a more complex perspective of philosophy of mathematics education, one that does not simply cut and paste a particular view of philosophy of education onto mathematics education. Ernest (2004) suggested that we ought to view philosophy of mathematics education not as a single position, but as "an area of investigation" (p. 1). Although Ernest does not offer a clear picture of what this position would look like in practice, I interpret this schema as upholding both the discipline of philosophy of mathematics and philosophy of education as complimentary, yet separate areas of inquiry that ought to influence mathematics education as well as further the objectives of each simultaneously. While this is indeed a broad conception of the field and not one of the aforementioned schemas, it is an important one to consider. Traditionally, research in education focused on the practices of teaching and learning of mathematics, such as what cognitive theories best-fit mathematics learning objectives and what types of classroom organizations best facilitate learning of mathematics. Philosophical investigations into these traditional areas of research are pertinent, and many scholars (e.g. Cobb et al, 1992) have conducted useful research, yet the broader societal realm has been left unanalyzed. Philosophical analysis can be put to work in uncovering the broader implications of mathematics education policy. By studying the interrelations through a metanarrative, as well as through a micro-level and bisectional view, we can gain a complex yet more enlightening view about what is really going on in the discourse about mathematics education, which is the objective of this work.

This new method of studying philosophy of mathematics education that I am advocating looks specifically into the way in which specific philosophical inquiries can be utilized in thinking through the interrelationships inherent in the meta-discourses of philosophy of mathematics, philosophy of education, and education of mathematics. In philosophy of mathematics, I pay specific attention to the ontological debates about the nature of numbers and mathematical axioms. These classic debates date back to antiquity and became especially popular in philosophy of mathematics during the late 19th an early 20th century. In philosophy of education, I pay important attention to axiological claims about what the objectives of mathematics education ought to be. This is a primary question of philosophy of education since John Dewey asked what democratic education ought to be and how it ought to be framed to best serve future democratic citizens. In mathematics education, I concentrate on pedagogical theories that specify the best practices for teaching and learning mathematics. And in mathematics, I am interested in investigating the ontological assumptions about how our society has come to view numbers and other mathematical identities such as functions and operations. The following section provides further background of these philosophical categories and explains how they can be utilized in research of mathematics education policy reform documents.

3.2. Axiology, Epistemology, and Ontology

In order to put philosophical research analysis more concretely to work as analytical constructs for the empirical section of this dissertation, a conceptual bridge must be established connecting the ontological assumptions about mathematics to the pedagogical practices thought best to teach mathematics as well as the overall objectives educational reforms attempt to serve. The philosophical discourses that are most advantageous for my inquiry are epistemology, ontology, and axiology (see Appendix A for standard philosophical definitions). Ontology relates to the conceptual assumptions we have about what mathematics is about (i.e. what numbers are, how functions and geometric properties interact with the empirical world). Epistemology relates to pedagogical theories as to how best to teach mathematics, which are based on a theoretical and/or research driven approach that claims children learn mathematical knowledge in a certain way. Axiology relates to objectives of mathematics education since objectives for the uses of why children should learn mathematics are based on broader normative views as to what mathematical knowledge ought to be used for. I have substituted ontology for metaphysics based on the belief that mathematics is a language that attempts to explain the existing components of the world and what types of structures, patterns, and relations such components make. This belief comes directly from Shapiro (1997) and Resnik (1981) account of mathematics as a study of patterns. Please see artifact 3 in this portfolio for further explanation into this theory. In what follows, I provide an overview of these three categories in mathematics education and explain how they have historically been implemented in education, and philosophically how they have been utilized to critique and/or aid inquiry into mathematics. (Refer to Appendix B for graphic display depicting how these categories will be used as analytic constructs for coding purposes)

3.2.1. Conceptions - Ontology

Conceptions of mathematics relate to both pedagogies of mathematics, and to objectives of mathematics education. Certainly, depending on what the objectives of mathematics education are, pedagogies of mathematics will follow, since curricula decisions are always tied to pedagogical decisions. Unlike epistemology, ontology has been extremely misrepresented in educational research. Unfortunately, the link between epistemic claims about how we gain mathematical knowledge is not related to where we believe such knowledge is located. There is an ontological question that always underlies epistemological claims. Whether one posits a purely semiotic view of mathematics as nominalists do or even a purely mental construct game of finite symbols, as intuitionists believe, ontological assumptions are inherent.

Without collapsing into sophistry, a philosophy of mathematics education must rest its theoretical musings on ontological presuppositions in the very least, since such presuppositions hold the fundamental view of what mathematics is and therefore always are foundational questions in the inquiry. Badiou (2003a) makes this argument in several of his books, especially in *Infinite Thought*, where he asserts that ontological inquiry has since Heidegger been left unfortunately unattended to. He explains that both the Western analytic school and the European continental schools of philosophy have abandoned the branch of ontology, focusing on epistemological inquiry and phenomenological questions respectfully. This is a travesty according to Badiou since ontological questions underlie all ways of understanding our world and thus are prerequisites for thinking about changing it.

Rowlands and Carson (2002) show how Badiou's argument can be used in the educational context. They fervently critique constructivists' approaches to pedagogy in mathematics by asking what ontological assumptions about mathematics are inherent in constructivist learning strategies. They make a rather convincing argument that we cannot escape ontological questions in philosophy of mathematics education since this will lead to a flawed theory of how to teach mathematics. Pragmatics might argue that ontology is irrelevant as long as the theory works in practice. This might be true for other subjects taught in school, but mathematics is intrinsically tied to ontology since it asks us to abstract from symbolic relationships possible values of unknown entities.

There are traditionally two ways of conceptualizing the field of mathematics. These can be understood as the dichotomy between absolutist and fallibilist notions of mathematics, where the former believes mathematics has a direct link to empirical or rational truths outside the human subject, while the latter posits that all mathematical knowledge is based on cultural, social, and political forces that are inherently flawed, evolving, and biased. Absolutist includes realism and some forms of formalism and intuitionism. Fallibilist includes nominalism and constructivism (Ernest 2004). Absolutism includes Formalism, Logicism, and to a certain extent Intuitionism and fallibilistic includes Nominalism, Constructivism. Fallibilistic accounts (e.g. Davis & Hersh 1980; Ernest 1994 & 2004; Lakatos 1976; Tymoczko, 1993) view mathematics as a humanistic discipline that is an outcome of social processes. Absolutism views mathematical knowledge as a direct byproduct of either deductive rational inquiry or empirical validation depending on where mathematical entities are posited (either mental or empirical). Certainty, these theoretical conceptions of mathematics rest upon epistemological views on how we gain access to mathematics knowledge and ontological views on what reality is made up of.

This simplistic dichotomy leaves much to be desired. Whether or not we posit an ontological status for mathematical truths or not, it is unclear how pedagogical practices ought to be affected. Indeed, neither seems very satisfactory given the complexity of the debates in current philosophy of mathematics discourses. Further, each camp seems to argue for their own view by critiquing the others or ignoring them altogether. Fallibilist ignore the paradigmatic paper given by Eugene Wigner, a mathematician, titled “the unreasonable usefulness of mathematics” (Burbaker, 2008). By ignoring the empirical uses that mathematical abstraction continues to play in science, fallibilistic accounts of mathematics loses tremendous credibility. On the other hand, by ignoring the Kuhn’s theories on paradigm shifts, such as the fallibility of Euclidean geometry, which is now unanimously agreed by professional mathematicians and scientists, absolutism accounts of mathematics appear stubbornly rigid and illogical.

A third possibility is what I have termed aesthetic conception of mathematics. Scholars have proclaimed the aesthetic dimension of mathematics as the key characteristic of the mathematical learning experience (e.g. Crannell, 2009; Sinclair, 2001;Tymoczko, 1993; Wang, 2001). Indeed, great mathematicians from Poincare to

Gödel have asserted that their practice of mathematics is latent with aesthetical experiences (Devlin, 2000). Even the National Council of Mathematics Teachers asserts that a connection to art and music ought to be achieved in the mathematics classroom. A particular example of a philosophy of mathematics based on aesthetics is Resnik's (1981) notion of mathematics as a study of patterns and Shapiro (1997) mathematics as a study of structures. Within these views, mathematicians and philosophers of mathematics are not concerned with the ontological properties or truth-values of numbers themselves, but only the structures and relationships that bind them together. Thus, the absolutism claim that numbers exist outside of human understanding as well as the fallibilistic assertion that numbers are completely part of a human cultural understanding of a particular worldview, make way for an alternative. This alternative is not a compromise or a synthesis of the two more popular dichotomous views, but an altogether new ontological conception of mathematics. Shapiro explains that on all versions of structuralism, the nature of objects in the places of structure does not matter – only the relations among the objects are significant. A simple way of understanding this is to realize that numbers are always in relation to one another. For example, you are only short compared to someone taller; a thousand dollars is either a lot of money or not that much depending on where you live and the lifestyle you are accustom to. The question is how does this conception of mathematics relate to an aesthetic ontological perspective? We should remember that ontology attempts to explain the parts or reality; in mathematics, ontology attempts to explain the nature of numbers, mathematical operations, and processes. It is how this ontological perspective translates to the experiences of doing mathematics that can also be viewed as aesthetic. Mathematicians discuss the creative process of working on a proof and the inductive nature of mathematics, which necessitates a recursive type of thinking and an intuitive sense that what one is doing may yield new knowledge to the field. Conceiving numbers as relations, rather than static entities or culturally meaningless terms, may elicit a more aesthetic experience in the practice of doing mathematics. This has great implications for education, especially at the elementary level when numbers are first introduced.

How do these three conceptions of mathematics compare to the meta-discourses discussed of ontology, epistemology, and axiology? First, we can say that epistemology and ontology are explicitly given precedents in absolutism and fallibilist accounts of mathematics. This might not be explicit in aesthetical conception of mathematics since the model I borrow from Resnik does not clearly define an ontological referent to the patterns mathematics is supposed to study. Instead, Resnik contends that patterns or relationships are all that exists, which by it I claim is an ontological view. Clearly, we can say, pedagogy will be conceived drastically different depending on which view of mathematics one holds, although as we will see in the following section, this may be an incorrect assumption.

Ethically, there may be specific dilemma that emerges within any given account of mathematics once it is put into the politically charged education system. Certainly, democratic ideals would change from absolutist and fallibilist accounts of mathematics since these assume different axiological objectives for mathematics education and thereby change the discourse in education policies. As the editors of *Math Worlds* contend, "mathematics itself is an expression of social relations" (Restivo, Bendegam, & Fischer, 1993, p. 15). Thus, the way we conceptualize mathematics directly relates to how we interact on a political and social level. It would seem then the three ways of ontologically viewing the conceptions of mathematics must be related to pedagogies as well as objectives of education. Mathematics, as it is traditionally taught and conceived of as an absolutist account, causes us to assume the world is made up of quantifiable entities. This belief allows us to construct objective standards with which to measure ourselves and to place value on such knowledge. On the other hand, if one assumed a fallibilist account of mathematics and utilize constructivist or political pedagogical approaches, our worldview might be altered in that we would not seek to determine value based on quantifiable measures.

Lastly, entertaining an aesthetic conception of mathematics, ontologically the topic becomes very interesting. Thinking about mathematics as a discipline that attempts to understand patterns and relationships provides an alternative to the historical aim of education as well as the pedagogies that have come forth to meet them. Here, mathematics education would aim to provide an aesthetic experience of doing mathematics, which would in turn inspire the imagination and bring forth the necessary cognitive apparatus needed to learn mathematics well. In addition, and this is my most far reaching claim, if we learn mathematics as a system of relations and patterns, our ways of conceptualizing our world and ourselves might change as well so that we would view connections to be explored rather than quantities to be measured.

3.2.2. Pedagogy - Epistemology

In this section I examine the various learning theories that have influenced the teaching and learning of mathematics. I differentiated these theories on learning mathematics into three broad categories: traditional, constructivist, and transformative. Epistemology, the philosophical branch that attempts to understand knowledge, is perhaps the most well known discourse in philosophy and therefore has much literature devoted to it. While science has been proven wrong at times, history is written through biases, and literature can be Eurocentric, mathematics has only in the last century been questioned as not a complete error-proof body of knowledge. This debate rages forward through constructivist theories on learning mathematics, various schools in philosophy of mathematics and poststructuralist critiques. Therefore, mathematics is the last school subject to lose its solid unquestionable stance on truth. Of course, it is difficult to gauge the general public's awareness of this trend in philosophy of mathematics and it is perhaps more difficult to understand how this idea has surfaced in philosophy of mathematics education. Traditionally, mathematics was taught as a static body of knowledge and unquestionable truth. However, recently policy discourses have implicitly disagreed with this claim (Sriraman & English, 2010). What is unclear in mathematics education policy is the distinct epistemological stance to support these positions. The reason for this shortcoming may be a lack of philosophical understanding or an unwillingness to be forthcoming with a position that may be unpopular. However, all pedagogical theories must rest upon epistemological assumptions; to disregard this claim is to cause undue ambiguity that disparaged the pedagogical objectives themselves.

After all, without a clear theory on knowledge, how can one expect to come to have access to it much less understanding?

Drawing from Vygotsky's dynamic social theory and perhaps Piaget's psychological theory of learning, Constructivist pedagogies are extremely influential in the discourses in mathematics education. In fact, the National Council of Teachers of Mathematics (NCTM) explicitly advocated constructivist methods in teaching mathematics in their 2011 Standards and Guidelines (Kelly, 2008). Hirsch in his book, *The Schools We Need: Why We Don't Have Them*, defines constructivism as:

> A psychological term used by educational specialists to sanction the practice of "self-paced learning" and "discovery learning." The term implies that only constructed knowledge—knowledge, which one finds out for one's self--is truly integrated and understood. It is certainly true that such knowledge is very likely to be remembered and understood, but it is not the case, as constructivists imply, that *only* such self-discovered knowledge will be reliably understood and remembered. This incorrect claim plays on an ambiguity between the technical and nontechnical uses of the term "construct" in the psychological literature... (Hirsch, 1996, p. 52).

The aims here seem to be more progressive and child-centered, however pragmatists aims are also often implicated since along side constructivist pedagogy, NCTM and other policy initiatives claim that such practices will help students learn the valuable mathematics knowledge they need to get a job. Constructivist pedagogies are often acclaimed in the literature on mathematics education. Constructivist pedagogies fall within two camps: radical and social constructivism. Generally, we can say that both constructivist pedagogies deny the classic correspondence theory of truth, which states that humans can have access to external truths. Both approaches claim learning is not a passive activity since the learner must construct all knowledge through direct experience with new information that must interact with already held knowledge to create new cognitive understandings about how the world works (Irzig, 2000). What is unclear is where exactly the knowledge, that the child actively constructs is found. This is where social and radical constructivism differs significantly.

Social constructivists believe knowledge is acquired through the social realm by consensus in a community of inquiries, be they mathematicians or students in a classroom (e.g. Kilpatrick, 2001; Hersh 1993; Valero, 2004). Radical constructivists (e.g. Ernest, 2004; von Glasersfeld, 1991), on the other hand, strictly say that knowledge can only be created through the subjective process internal to the learner himself. Constructivists claim that theirs is a "theory of learning and not a theory of knowing, that it is a psychological theory about how beliefs are developed rather than what makes beliefs true, that it makes no ontological claim concerning the external world and that it is 'post-epistemological'" (Rowlands & Carson, 2002 cites Matthews 1998)**.** Social constructivists claim that knowledge is content specific and negotiated through socially mediated activities. But how does this explain the practice of applied mathematics as Eugene Wigner so eloquently wrote about in his famous essay "The unreasonable effectiveness of mathematics".[2] Moreover, how can constructivism pedagogies offer clear methods for learning mathematics, a body of knowledge that has been developing for centuries in a span of a typical mathematics lesson?

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[2] This essay has been cited repeatedly to argue against the postmodern position that knowledge is strictly social.

Social constructivism claims parallel Vygotsky's theories on learning, however their epistemological claims over extend into vague philosophical terrain that causes undue difficulty. Vygotsky himself never endorsed such a radical break from ontological orthodoxy. And certainly, not Piaget who believed biological components had a large role to play in the learning process. Generally, we can say that both constructivist pedagogies deny the classic correspondence theory of truth, which states that humans can have access to external truths. Perhaps they would say it is not that ontological reality does not exist outside of our minds, but only that we cannot have access to it. This philosophical claim is not supported by transcendentalism or any other coherent theory, though, thus some scholars have argued that constructivism merely dissolves itself into solipsism (Rowlands & Carson 2002 cite Chalmers, 1982). Further, "constructivist activities aim to answer the 'so what?' questions for students, but do so within the given conceptual scheme, taking for granted the ontological primacy of mathematics (de Freitas 2004 p. 260 cites Popkewitz, 1998, p. 28). This is a severe drawback since mathematics is very much an abstract creative discipline that can be difficult for many to learn. Perhaps the difficulties in learning lie not in theorizing alternative pedagogical techniques, but in envisioning how ontological conceptions of mathematics influence the way in which students come to learn higher-level mathematics.

Due to social constructivism's ambiguous philosophical foundation as claimed by critics of constructivism as a pedagogical theory, there are several consequences for the mathematics classroom (Rowlands & Carson, 2002). Consider this strong argument against constructivist theories:

> If knowledge is nothing more than what is constructed by the individual, then the learner is never wrong - whatever has been constructed has made sense and whatever makes sense is knowledge! If truth is whatever the learner considers to be the case, then there is no body of knowledge, no ‘subject-matter’ that can be taught as such (Rowlands & Carson, 2002, p. 3).

How can it be possible to attain a high level of understanding of the richness of mathematics if one cannot be shown where and why certain mathematical operations have been done incorrectly? Wittgenstein aside, students would be quite perplexed if their teacher proclaimed that two plus five did not equal seven. Certainly, philosophical reflection on number existence has a place even in elementary mathematics learning, but this requires a teacher who is well versed in different ontological theories in mathematics.

Radical constructivism fares no better than social constructivist theories for educational practices. This is because algorithms in mathematics, although cognitive construction of mathematical procedures that work arose from many different people through many different ways, converged their expertise to form a consensus as to what constitutes correct computational skills in mathematical practice and this consensus was not formed by accident, but by application to how the procedures best fit empirical evidence and abstract proofs that stood the test of expert mathematicians of the times. To stress, mathematical practices did not happen by accident and to expect children to form their own algorithms without giving them the necessary deep cognitive understanding of the field of mathematics is time wasted at best and absurd at worst. Another drawback to this approach is that the teacher in radical constructivism is reduced to a mere “facilitator” who has little expert advice to bestow on the children entrusted in his care. This role is particularly damaging given the recent efforts towards dismantling teachers’ unions and the public's seeming disdain for the "bad teachers" in America; it is damaging to reduce a teacher to a facilitator, since such a role could be played by a software program or anyone not specifically trained in democratic and pedagogical aspects of the professional field of being an educator. In addition, democratic ideals seem to be completely ignored or at least simplified to only being about providing access to knowledge. But since this knowledge is not explicitly linked to empirical reality and only vaguely linked to individual or societal subjective spaces, democratic praxis is practically impossible in this learning theory.

It seems straightforward to connect constructivism to fallibilist notions of mathematics, since knowledge is not seen as universal truth, but rather created by social and individual contexts embedded within societal and cultural spheres. Constructivism differs from traditional pedagogies, which favor an absolutist view of mathematics. More complicated is to ask how the aesthetic conception of mathematics compliments or opposing these two pedagogies. At first glance, a constructivists classroom would seem to foster a more aesthetic experience however, if mathematical knowledge is believed to be strictly socially construed, certain important, dare I say mysterious, components of mathematics are lost. For instance, students without fail are enthralled when I bring up transcendental numbers in my classroom. Activities may include counting the petals of a daisy, or figuring out the reproduction of rabbits (classic Fibonacci problem showcase the infamous Fibonacci series as it relates to natural phenomena). We also measure our own bodies to investigate its beautiful number proportions and "discover" pi by dividing the the circumference by the diameter of any given circle. These lessons would lose their aesthetic appeal if they were somehow reduced to just being about knowledge created by human societies, rather than being about how mathematics can show us intrinsic patterns that occur in nature and in ourselves.

A third epistemological alternative that has influenced pedagogical theory and research can be termed transformative pedagogy. This alternative is different from constructivist and traditional approaches to teaching and learning mathematics, since it assumes at the forefront that power relations are at the core of mathematical activities and therefore must be made explicit in the education of mathematics. Transformative mathematics pedagogies concentrate on not only exposing the power relations that mathematics holds in a society, but also utilizing such power to transform a learner into a critical agent of change within the society. In what follows, I describe two transformative pedagogies, ethnomathematics and critical mathematics pedagogy.

Ethnomathematics is a pedagogy that stresses that mathematical knowledge was generated in the continual context of cultural history (D'Ambrosio, 2001). In this sense, ethnomathematics is a political and ethical theory of pedagogy that attempts to resist hegemonic Euro-western ideology in order to reestablish epistemological alternatives that are found in indigenous cultures. Ethnomathematics certainly has much to offer, in that it broadens our cultural awareness of indigenous cultures, critiques western positivists claims on mathematics knowledge, and ethically puts into question how mathematics has historically marginalized certain groups of people.

In terms of pedagogical theories, ethnomathematics may be more of a curricula framework that a theory of teaching and learning. Thus, both types of constructivism as explained above could compliment ethnomathematics nicely since neither is interested in ontological assumptions but rather strictly considered with epistemology. Traditional pedagogy would be the antithesis to this approach since it assumes that knowledge is stagnant and universal, both claims which ethnomathematics disagrees with. To relate ethnomathematics to conceptions of mathematics, a link can be made with aesthetic conceptions of mathematics. Ron Eglash (2002) is a mathematician who studied villages in South Africa and found that they were constructed with a sophisticated understanding of fractal mathematics; not only this, but when he spoke to the villagers, they were completely aware of the mathematics behind the construction and could explain the mathematical properties in extremely high degree of mathematics comprehension.

Ethnomathematics claims a fallibilist ontology, yet it is unclear if the knowledge is strictly culturally produced and as such how can it say which system of mathematics ought to be taught other than the one that is currently dominant in the western modern world? Here, ethical pursuits seem most pertinent to ethnomathematics agenda. By trying to show the importance of other culturally known mathematics knowledge, ethnomathematics attempts to provide an empathic view of globally diverse systems of knowledge, with the hope that such information would facilitate a deeper awareness of global problems in the mathematics learner.

The weakness with this educational alternative is that it rests on little epistemological support or ontologically clear assumptions, and is not grounded on any specific political agenda. Katz (1995) argues the epistemological incoherence in ethnomathematics, since there has been historical proof that mathematical “discovers” have arisen in separate locations; for example the Chinese and the Greeks independently figured out the Pythagorean theorem and Pascal's triangle. Further, ethnomathematics does not take into account the political and historical events that have led to the marginalization of certain knowledge over others. For instance, teaching urban U.S. students about African villages does little to give them an understanding of how and perhaps why such villages have been colonized and continue to be places of intense human hardship. More to the point, teaching villagers in Ethiopia about their own culture's contributions to the mathematics discipline lends little real support in their political and personal struggles of survival in a globally connected world that is dominated by a western view of mathematics (Skovsmose, 2006).

Ethnomathematics may serve as a corollary to mathematics education, but it cannot be substituted in any way to the larger growing body that is the western known mathematics discipline, neither for pedagogical gains nor political gains. On the other hand, aesthetic aspects of ethnomathematics could add considerably to the learning experience of students. A more direct link between the political and education is made with critical mathematics pedagogy.

Critical mathematics pedagogy (e.g. Frankenstein, 1983; Gutstein, 2006; Skovsmose, 1994) was inspired by the work of Paulo Freire, who proclaimed that revolutionary leaders must also be educators. Freire's epistemology is antithetical to the Western positivist paradigm in that it views mathematics knowledge and education as never neutral; rather than a set of value-free objective truths, mathematics is seen as creating power relations among different groups of people and then legitimizing these dichotomies to serve the needs of a powerful ruling class. Hence, this pedagogy can be viewed as a fallibilist notion of mathematics, since it assumes power is created and controlled by an elite class and by changing the way in which mathematical power is conceptualized such power relations can be overthrown. I do not see an aesthetic correlation unless we can argue that fostering a political agency is an aesthetic experience. However, I do see a direct relationship to radical constructivism since the individual gains access to knowledge directly which may harness the critical "consciousness" critical pedagogues hope to achieve in the classroom. What is interesting for modern education of mathematics is that Freire saw how "massified" consciousness is more prevalent in technological societies such as ours and is a major factor in determining the inability of subjugated people to actively engage in their own revolutionary agendas. Thus, developing critical mathematics pedagogy becomes increasingly urgent as our society becomes even more technologically saturated. Skovsmose (2006) expressed that "mathematics education also tends to contribute to the regeneration of an inequitable society through undemocratic and exclusive pedagogical practices" (p. 3).

Critical Mathematics Pedagogy strives to empower students by enabling them to gain the tools needed to "read the world," and thus have the ability to transform it (Atweh, 2007, p. 7). Unfortunately, there has been no empirical proof that there is a causal relationship between one becoming aware of social inequalities and then becoming politically active in order to bring about change. The possible reason for this disconnect may be due to failing to question hard enough the epistemological and ontological assumptions inherent in how mathematics is perceived. Brantlinger (2011a & 2011b) began his own academic career as a action researcher who passionately believed in critical mathematics pedagogy and used it in an urban classroom to empower his students. However, during the course of his research, Brantlinger became increasingly skeptical of critical mathematics perspective. He writes

> Although I see benefits to critical pedagogy, I am wary of critical and other utilitarian versions of school mathematics that explicitly or implicitly eschew value of disciplinary-focused school mathematics…it is essential that critical educators better understand the powerful gatekeeper role that school mathematics serves before we reconceptualize school mathematics as a critical literacy for some students (2011b, p. 98).

Among other research projects Brantlinger worked on, his textual analysis of textbooks and found that the critical mathematics agenda is problematic in terms of equity in urban districts in the U.S (2011a).

As arguments previously presented, ontological assumptions are inherently presupposed by certain epistemological stances, which thereby dictate democratic ideas. Concretely, we can say that a positivistic/empirical stance corresponds to an ontological view that there are indeed certain entities, in mathematics, that might mean abstract universal concepts of numbers that are outside human social construction. Inversely, if we take a more formalist or nominalist approach to mathematics, this would garner a view that mathematical knowledge does not exist apart from its historical social context. Positing these two extremes for democratic activism can lead to drastically different results. I believe the disconnect between learning to be math literate and then engaging in praxis to make the world a more just and peaceful place lies in the inability of critical mathematics pedagogy to provide a concrete understanding of how mathematics itself frames our world and how we can use it to reformulate it in our own design. This type of understanding, of course, also needs a high cognitive knowledge of mathematics as well as an imaginative potential that can be fostered by aesthetic experiences in the mathematics classroom.

Transformative Pedagogies are important to discuss since they are often are the product of a particular critical stance to philosophy of mathematics education. Moreover, they evoke an ethical appeal to democratic objectives that are often missed in both traditional and constructivists' pedagogies. Transformative pedagogies as do constructivist pedagogies seem to also fall within the fallibilist camp of mathematics. This seems unproblematic, until we ask if there is a consequence to ignoring the other two conceptions of mathematics.

3.2.3. Objectives - Axiology

Axiological inquiry has traditionally encompassed ethical issues in education and concentrates on the teacher/student relationship or other classroom-specific dimensions, but this is not my current interest, which is to understand the link between society and mathematics. Philosophical discourses on ethics in mathematics have also brought up the historical ties of the field (Fried, 2007). Most generally, we can say that mathematics since antiquity has been integral to many of humankind's greatest accomplishments and most deplorable acts (D'Ambrosio, 2001).

Not only has mathematics knowledge had ethical consequences; it can also be used for political possibilities. The connection between politics and ethics is essentially tied to the ideology behind democracy. Gutstein (2006) asserts that mathematics ought to be used for radically new democratic agendas, which can raise consciousness about the unjust practices of society. Thus, the philosophical domain of ethics seems to be the strongest link since it ties epistemology and political concerns of mathematics education together. Moreover, ethical inquiry may be better able to bridge the gap between epistemology and ontology. Political questions assume a particular stance on epistemology and thereby ontology. Ethical questions assume slightly less and therefore begin more at an opening of inquiry. Ethics also asks us to conceive of alternative possibilities; these possibilities may also stem from our misrepresentations of the world and the things within them. Hence, thinking about ontology can add a useful reflection to ethical questions.

Ernest (2004, p. 6) identifies five discrete aims of mathematics education.

1. Industrial Trainer aims - “back to basics,” numeracy and social training in obedience (authoritarian)
2. Technological Pragmatists aims – useful mathematics to the appropriate level and knowledge and skill certification (industry-centered)
3. Old Humanist aims – transmission of the body of mathematical knowledge (mathematics centered)
4. Progressive Educators aims – creativity, self-realization through mathematics (child-centered)
5. Public Educator aims – critical awareness and democratic citizenship via mathematics (social justice centered)

I have collapsed these five into three categories: utilitarian, cognitive, and democratic aims of education, to help categorize the aims of mathematics education as they currently exist in current reform discourses and to work as analytic constructs in the coding of the policy documents. While these are non-exclusive categories, they help differentiate the different axiological views embedded in U.S. national education policy documents.

Utilitarian aims encompass the first two of Ernest's categories, since the commonality is that mathematics education ought to provide the skills and knowledge needed for a productive adult life, whether that means getting a competitive job in a global marketplace, or understanding how to balance a checkbook and get a mortgage as a competitive citizen. Cognitive aims assume that only learning high levels of mathematics ought to be the central import for education, thus this category relates best with the humanist aim, but I argue the Progressive aims may fit as well since these are also interested in the direct learning comprehension of the mathematics student. Here, this rests on axiological missions in past reform efforts such as "New Math." Democratic aims for education include progressive aims, but most certainly include the social justice aims. These assume that mathematics education should serve to help citizens gain numerical understanding for literacy in a modern technological driven world. In addition, democratic aims can also encompass critical mathematics mission for using mathematics to uncover social injustices.

To give some concrete examples, utilitarian aims of mathematics education can be seen more concretely in reforms such as the America Competes Act that asks schools to produce workers with the technological knowledge our nation needs to maintain its competitive edge in the global marketplace. Utilitarian aims also can be depicted by the Workforce Readiness Taskforce, which wants schools to produce competent future workers. In addition, the call for private corporations to become increasingly involved in education is a direct result of utilitarian objectives in education reforms.

Cognitive aims are represented through the "Back to Basics Act" as well as the "New Math" reforms since both opposing educational aims attempted to provide students with pedagogical techniques and curricula enhancements that would facilitate a high level of understanding of mathematics. The difference between these two reform packages may be their conceptions of mathematics, as well as the pedagogies they employed. For instance, in the Back to Basics reforms, absolutist conception of mathematics was more prevalent as well as traditional pedagogical approaches. In the New Math reform, the aesthetic conception of mathematics could be seen, as well as certain constructivist and political pedagogies utilized. Interestingly, one can also see the correlation between cognitive aims and constructivist strategies for learning with utilitarian aims of education. Gatto (2003) argued that industrialists, notably Carnegie, Morgan, Rockefeller and Ford, shaped public schooling in the U.S. in order to produce a docile and efficient workforce (e.g. Greer & Mukhopadhyay, 2003). Indeed, knowledge, either perceived as socially agreed upon or existing in a platonic realm, makes no difference in the ends such knowledge ought to be used for.

Democratic aims are the most difficult to pin down, since as I explained in Chapter Two (p. 19), policy in the U.S. tends to evoke democratic objectives as part of the overall discourse (Stone, 2002). For example, the *No Child Left Behind Act* at least rhetorically claims to work towards this end. In regard to conception of mathematics, it would seem fallibilist claims seem to relate most easily to this objective since the cultural status of numbers would help loosen the western hegemonic power of mathematics.

Certainly, the political pedagogies seem to correlate the easiest with democratic aims however, this all depends on what definition of democracy one is using.

It would seem that utilitarian and democratic aims for mathematics education are the antithesis to each other, but this may not be the case. Indeed, in the current policy discourse, these two are completely intertwined. Similar to Steen's argument for math literacy in a technological world, mathematics education is believed to be primarily for gaining the knowledge of mathematics that can best serve an individual living in the U.S. If one believes that the U.S. is a functioning democracy, then it would be perfectly reasonable to use the meritocracy argument that mathematics education ought to aim to provide the knowledge and skill set needed to earn a living wage. On the other hand, if one is a critical pedagogue as Ernest's public educator aim depicts, democratic aims of mathematics education assume a much different agenda.

A philosophical analysis of education policies can illuminate much about how our society comes to value mathematics and this information can help educators and researchers understand the complex discourses surrounding mathematics education reforms. Since my contention at the forefront of this work was that ontological categories of mathematics are inherently part of the discourse and ought to be uncovered, I have studied and incorporated, as a theoretical lens for this dissertation, the philosophical work of an influential and perhaps controversial figure in contemporary philosophy today, Alain Badiou.

Chapter 4: Theoretical Lens

This chapter describes the theory that offers the lens in which I used before, during, and after the analysis of the policy documents. It also drove the theoretical lens that anchored my philosophical disposition throughout this dissertation. A contemporary French philosopher writing today, Alain Badiou's philosophical work is highly useful for understanding today's political climate in education, especially in the field of mathematics. Badiou's philosophical corpus is enormous and is only beginning to gain momentum in influencing the English speaking philosophical community. As his many volumes of books and essays get translated into English, Badiou's unique philosophical pose and theoretical thought continue to stimulate modern philosophers working in various fields, one of which is philosophy of education. His work is most recently being utilized in theorizing revolutionary ideas in education (Barbour, 2010; Brown, 2010; Hallward, 2006; Lehman, 2010; Lewis & Cho, 2005). My use of Badiou's theoretical work is one of the first to specifically focus on mathematics education (Brown, 2010). I believe it may be the first to incorporate Badiou's methodology in analyzing education policy documents. In this chapter, I give background onto Badiou's most well known concepts and explain how these concepts relate to the work I have done in this dissertation study.

The following sections delve through Badiou's philosophy from general to more particular, and from abstract to more concrete. First, I discuss how Badiou's work is significant for thinking about mathematics and its place in society. Next, I move to mathematics education and then more particularly to teaching mathematics in a public school setting. Last, I explain how I utilized Badiou's philosophical methodology for the empirical work in this dissertation.

4.1. Ontology and Mathematics

One of Badiou's most famous statements is that "mathematics is ontology," or more specifically, mathematics is the only discourse that can think ontologically (Badiou, 2005a). Ontology, as defined by Badiou, is "a world" or "a situation" or more simply, it is what is presented in the world. His ontological axioms begin with a proclamation that "an objective situation in which subjective truths are at work is never anything other than a multiple, made up of an infinity of elements, which are themselves multiples" (2005a, p. 65). His ontology of the multiple directly opposes traditional Hegelian and classical Platonic views of unity and oneness, which posit that there is some causal determinate that necessarily exists before all else comes into being or that exists beyond in the realm of forms that gives essential structure to the world around us. For Badiou, the multiple is an ontological truth, and a method for understanding its relation to the world around us is axiomatic set theory, a modern branch of mathematics. Set theory enables mathematicians to study sets, defined as a collection of objects, typically conceived of a mathematical entities, but also could be more simplistically defined as groups of any objects, such as people, pencils; for example, a set can be a collection of objects on my desk, which at this moment happen to be a lamp, pencil, phone, and computer. Thus, the set of objects on my desk (at this particular time and place) are a lamp, a pencil, a phone, and a computer. A more mathematical example of a set is the set of all factors of the number 12, which are 12, 1, 2, 6, 3, and 4.

The contention that reality consists solely of multiplicity, is a philosophical position that Badiou holds, which brings him to the conclusion that the language of set theory allows for multiplicity to be explored, since it only posits elements that can be themselves sets of sets. In mathematics, being can be thought, but perhaps not known completely insofar as mathematics is a meta-discourse that, while speaking about being, has no means for deciphering it. Mathematicians therefore use the language of being in their proofs and theorems, but never gain the ability to fully understand the meaning of the mathematical language that they themselves utilize. Influenced by Russell, Badiou explains,

> Mathematics is a discourse in which one does not know what one is talking about nor whether what one is saying is true. Mathematics is rather the *sole* discourse, which 'knows' absolutely what it is talking about (2007, p 8).

The reason for this, according to Badiou, is that mathematicians are interested in gaining knowledge, not uncovering truths.

An important distinction for Badiou is that truth is not equivalent to knowledge. In Badiou's framework truth is subtracted from knowledge just as being is subtracted from the void, which is defined as "something that exceeds the recognized differences in any given situation" (2005a, also in Barbour, 2010, p. 255). The distinction between knowledge and truth is strikingly different from the current philosophical tradition, which claims only epistemic knowledge can be known and truth is only relative to the cultural paradigm from which it emerges. Badiou states that there are only four possible discrete conditions for truth to be produced (events); and it is within this discourse that Badiou sees the possibility to think the infinite, which in his conception is multiplicity or a multiple within multiple. This is why he insists that mathematics (particularly set theory) is the language of ontology, because it is the only language that can depict the multiple of things directly. Since being is pure multiplicity in Badiou's framework, mathematics, particularly set theory, is the rightful discourse to capture being at its essence.

In a twist on traditional Platonic disposition, Badiou does not believe mathematics has any objects, but rather, mathematics is a discourse. "Math is not a game without object, but a discourse of ontology" (2007, p. 5). Of course, this doesn't help us understand what are ontology and its role in the situation. Badiou defines ontology as an "unfinished science trying to organize the discourse of presentation: (ibid, p 8) and "ontology is a situation, which is presentation" (ibid, p. 25). This is true because ontology is not being but merely attempts to organize it. Being, cannot be known, it can only be "saturured from the void" (ibid p. 10). If mathematics is ontology, then a philosophy that studies mathematics is akin to meta-ontology since it only presents presentation itself and not being; however, through its discourse we may come to understand where and how the *void* might emerge and therefore where *truth events* may occur and how *subjects* are created by their fidelity to these events. These are technical terms that mean specific things and are well defined by Badiou. As I progress through this chapter Badiou's terminology will be explained in detail.

If, according to Badiou, multiplicity is all that exists, the modern way of understanding numbers as discrete quantities is false. Yet, this pure "inconsistent multiple" is unthinkable and can only be represented as a "consistent multiple," which only occurs by an operation, Badiou terms the "count-as-one" that renders multiplicities measureable and perceptible (2005a). However, according to Badiou, the pure multiple can be retroactively understood by using the Zermolo Frankel axiomatic set theory. This is because utilizing a formal math language such as set theory, one does not need to define the tools which one is using, only considering how well formed they are. Set theory allows the multiple to be thought since it does not try to understand the single entity of number, but is only interested in relationships or structures that numbers belong to. This interest in structures and relationships can be characterized, at least in my framework here, as an aesthetic ontological category. Resnik's (1981) definition of mathematics as a study of patterns and Shapiro's (1997) emphasis on structures in mathematics upholds the ontology of the multiple a Badiou has defined. Numbers in an aesthetic ontological view are conceptualized as only real insofar as they relate tone another, in a non-hierarchical structure. Thus, unlike the philosophers of ontology that came before him. Badiou asserts that unity does not exist, but only multiplicity. As with numbers, a number cannot exist without the set to which it belongs to. For example, the real number 4 is in the set of integers, which is itself a subset of rational numbers, which is a subset of all real numbers, and so on. This ontological category provides a different ontology for thinking about how mathematics is conceived and therefore has implications for mathematics education and its policy reform discourses. Understanding numbers as relations necessitates a pedagogical method that is more holistic and perhaps more cognitively intensive. Moreover, viewing numbers as relations changes the way in which they are utilized in standardized tests and other quantitative means for assessment of teachers and students since quantifiable results must be measured only in terms of them and not presented as static objective truths.

Next, I relate this theoretical framework back to this dissertation and its overarching goals of exploring the coherency in policy documents as they relate to axiological objectives in education, epistemological claims about how best to teach and learn mathematics, and ontological assumptions that form the foundation for the others in the sense that they ground the claims and objectives in terms of a particular conception of mathematics. Searching for coherence in the policy discourse, I hoped to find the unifying constant that could explain how the various components of mathematics education related to philosophies of mathematics and philosophies of education. However, viewing this objective in a theoretical Badiouian sense changes my dissertation goal since unification is always ontologically a multiple. If multiplicity is the constant then I had to ask myself throughout the study, in what ways can coherence exhibit multiplicity? If it cannot, then perhaps coherence must be redefined in a more philosophical manner to account for the mathematical reality as Badiou sees it. This question is explored in depth during the last chapter of the discussion Chapter (7.4)

4.2. Mathematics Education in a Badiouian Lens

Galileo believed that the world "is written in the language of mathematics" (den Heyer, 2009, p. 233). Badiou agrees, and believes strongly that the present world adheres to a classical schema, which through the centuries has given humankind the tools and methods for learning about the reality in which we live. After all, without mathematics very little of humankind's accomplishments, such as skyscrapers and medical breakthroughs, and travesties, like the nuclear bomb, could have been achieved much less imagined. Technological advances from computers to all forms of digital devices rely on knowledge that applied as well as abstract field in mathematics provides.

Mathematics has done more than simply provide an arena for abstract thinking or a language for gaining knowledge about our reality; it has been argued that our perception of mathematics frames our possible way of seeing the world, thereby excluding alternative conceptions of reality (Warnick & Stemhagen, 2007). Badiou writes that "Learning about mathematics, we come to also see ourselves as mathematical beings." (Fried, 2007, p. 219). Rarely do we stop and ask ourselves in what ways has our knowledge of mathematics structured our lives? This is an ontological question, since the way we perceive our life is directly related to language and societal norms that are constructed or are constantly being constructed that define and give meaning to us.

Mathematics, being fundamental to our society, engulfs our perception of our world; it does this by framing how we understand economics, politics, religion, education, and ourselves, and even personal matters such as love and identity. For example, reflect upon to what extent our identities are structured around how much money we make, the size of clothes we wear, our credit score, and our income, and even the number of friends we have on *Facebook*. In love matters, remember your first love and how it was compared on a continuum scale with previous lovers and imagined future ones or with quantitative speculation on how compatible two loves are in respect to their birthdays, incomes, and desired leisure activities. Even more to the point, numbers are not contested and are typically viewed as valuable important bits of knowledge.

Mathematical language influences all aspects of our lives and therefore it is my contention that this language ought to be the utmost concern for educators and educational theorists, particularly ones that question the social injustices that are present in our society.

Number, an ontological entity for Badiou, is not an objective measurement device, rather it is “a form of being” and our incessant propensity to control and manipulate “Number” has led to a collective amnesia that is the cause and effect of our human condition. Badiou writes:

> In our situation, that of Capital, the reign of number is thus the reign of the unthought slavery of numericality itself. Number, which so it is claimed, underlies everything of value, is in actual fact a proscription against any thinking of number itself. Number operates as that obscure point where the situation concentrates its law; obscures through its being at once sovereign and subtracted from all thought, and even from every investigation that orients itself towards a truth (2008, p, 213).

Thus, if we seek a new definition of number, an alternative conception of mathematics, and a new method for teaching it, certain societal norms and values may change as well. For example, we would no longer value economic status as depicted by our bank accounts and earning statements to justify our worth; instead we may value how close our friendships and relationships are and what positive influences we have made. Simply, this is a question of how we come to perceive reality, as either quantifiable discrete parts or as relational interconnected points.

Badiou, like many European philosophers that came before him, is interested in political and social revolution. The axioms of mathematics allow Badiou to think about any given political or social situation in entirely new ways. But it is not just how mathematics thinks, but what or more specifically who is doing the thinking. Badiou's underlying assertion is that alternating our perception of what is a number can change our political and social organization in more democratic ways, and then it would be reasonable to evoke such a change in the education of mathematics itself. After all, it is within the discipline of mathematics that number is defined without critical reflection, and it is within the teaching and learning of mathematics that such concepts are propagated and not questioned. The critical theorists of critical mathematics pedagogy were right to claim that education of mathematics is the rightful place for higher consciousness to emerge, yet they did not dig deeply enough to wonder exactly how such changes may take place and from where they stem. The importance of mathematics as a pillar of our modern western paradigm assumes there are ontological assumptions about what elements exist in our world and how they are structured. These premises are part of the hidden curriculum in mathematics and ought to be uncovered. By exposing how we are trained to perceive reality based on the way we learn mathematics, we can then seek alternatives within the discourse of mathematics itself. Thus, the past efforts in political pedagogies have failed to ignite real social change not because they were not worthy of such work or that such work was not extremely worthy in itself, but because they failed to see the underlying condition that necessitates the current inequalities that have characterized our society for so long.

What does this new notion of mathematics change about how we can think about mathematics education and the policies enacted to better it? "Badiou sees the role of mathematics as pivotal to a reversal of the excesses of postmodernity on the one hand and analytic philosophy on the other" (Peterson, p. 15 in den Heyer, 2009). Both poetry and mathematics are key possibilities for eventual sites. These eventual sites are Badiou's terms for particular times and places in history where newness can emerge, such as revolutions, a new movement in art or music, a new theory in science or math, a new romantic love affair, etc. Poetry is key for Badiou as an eventual site since it alters the way in which we understand and utilizes language, thereby opening a space for new awareness of ourselves and allowing our reality to emerge. Mathematics, on the other end of the truth conditions, can only name the space where the changes can occur. Thus, it doesn't so much as create these spaces, but the pivotal discourse for seeing it. Let me explain these truth conditions further.

For Badiou, there are four places for newness to occur (politics, science, love, and art). These truth events happen at a point at the edge of the void, which is defined as the space in which what is presented in a situation suddenly appears to some subject who becomes aware of its presence yet knows that this variable was never represented in a normal situation. In mathematics education, this void can be found in situations where we become aware of the ontological status of mathematics. According to Badiou, the void can only occur within particular contextual situations, which are always subjective in interpretation; yet, although they are universal in the sense that everyone can be privy to them, I cannot name the specific conditions by which such situations arise, nor can I generalize anything about them. Therefore, I can only offer my own experiences as a mathematics learner and teacher for examples. As a student, I remember for the first time understanding calculus and the magnitude of its power. I remember a visceral realization of humankind's achievement and a faint glimmer of comprehension to how we could have landed on the moon. This awe-inspiring moment ignited a passion in me to learn and inspired a deep conviction to offer such knowledge to students that may have never thought they would be able to understand it. In the Badiouian sense, I became a subject of mathematics and have been faithful to that event thus far in my life. As a teacher, I remember teaching proportions and seeing the struggling faces of my students. I stopped right in the middle of my lesson and asked my students if they knew the formula of how to find the area of a circle. When they said they did, I asked what it means and how that formula was founded. We spent the next several weeks discussing two transcendental numbers, pi and phi, and how they arise from the relationship (ratio) of two other numbers. These sets of lessons and the interactive activities that encompassed them changed the very climate of the classroom. Students exclaimed that they never knew math was like this and that they now enjoyed doing math. This enjoyment changed the way in which students interacted with the subject of math and the very way they thought about numbers, formulas, and operations in mathematics.

What these stories have in common is an aesthetic response to learning insomuch as the experience of doing math strives to create a space for passion and fun in the classroom. However, there might be a clear distinction between the ways in which aesthetics is discussed in art versus the way it is conceived in mathematics. Aesthetics in mathematics, at least in the way I am utilizing it in this dissertation, is about ontology; thus conceptualizing numbers and other mathematical entities as relationships is an ontological category that stands as an alternative to the absolutist and fallibilistic ontological perspective. Badiou in *The Handbook of Inaesthetics* (2005b) theorizes that the connection between art, philosophy, and education. He writes, “the norm of art must be education, and the norm of education is philosophy” (p. 3). Further, “art itself that educates because it teachers of the power of infinity held within the tormented cohesion of a form” (Ibid, p. 3). As Badiou explains, the link between art and philosophy is education; therefore it may be through education that aesthetics can be conceptualized in terms of mathematics. “Inaeshetic education aims to loosen the hold of sensibility on the minds of the populace, and ideally, to corrupt the youth” (Lehman, 2010, p. 177). Since both art and science are sites for truths to emerge, it is absolutely imperative for educators and philosophers to take notice. This might be especially true for mathematics since more and more art programs are being removed from the public school curriculum. While mathematics education cannot substitute for the aesthetic experiences students learn in a pure art class, it can however infuse art within its structure. Perhaps, as many have argued (Dehaene, 1997; Devlin, 2000; Sinclair, N., Pimm, D., Higginson, W. editors. (2006), this combination will help students learn high level mathematics more effectively.

What we must remember when thinking about philosophy of mathematics education is that philosophy, according to Badiou, does not produce any truths, however it “seizes truths and shows them, exposes them, announces that they exist” (2005a, p 14). Philosophy’s role is akin to meta-education or perhaps policy critique, since it arranges and exposes truths and attempts to disseminate them to a universal address. There are two educational themes to take away from when viewing mathematics from a Badiouian lens, a practical one that can be used in the contextual particularity of a mathematics classroom; the other is a methodological one that can assist theorists and educators to make sense of policies at a more philosophical level. The next section deals with the former, and the last section in this chapter will deal with the latter.

4.3. A Subject of Policy

Any type of political action requires a human subject to become aware of *an event* in which such truths become present. A subject emerges out of this recognition and the ongoing fidelity of this truth. But, to be a subject is always a wager – "throwing of the dice" since the event, which comes from the void, "emerged within its own disappearance" (2005a, p 195). The intervention that the subject makes is in discriminating, proclaiming, and being faithful to the event, is never necessary, and always a choice. Further, the subject retroactively posits the event took place and through her recursive mode of inquiry discerns positive attributes of the event.

To explain more about what Badiou means by "the event," he defines it as on the edge of the void, not represented in the situation, yet belongs within it, not normal yet a singular multiplicity. The event is external to mathematics ontology, yet it is infinite potential at any given time and is equilaterally given as a universal possibility for all to bear witness to. For Badiou, "every radical transformational action originates in appoint which, inside a situation, is an eventual site" (ibid. p 176). Therefore, in order to extrapolate what Badiou's philosophy of the Event can offer to pedagogy, we must be insistent, as Badiou himself is, that the event is universal in its possibility, yet always emerges in a contextual particular space and time. This brings us to the public school mathematics classroom and to the teacher, who is juggling top-down policy initiatives, national standard curriculum principles and guidelines, and local rules and regulations, not to mention particular student dispositions and learning styles.

To be a teacher in the Badiouian sense is to become subject to the truth when and if it emerges. This is because the teacher must reside in both realms simultaneously, the abstract and the particular, the practical and the theoretical. The dialectic continues, the teacher must be empathic to the students, yet authoritative on arguably several levels. The teacher is the exact point of entry between the policies as it is stipulated by policymakers and the selected receivers of said policy – the students in the classroom, for whom the policy is articulated. Teachers should have full knowledge of policy, which will give them agency to see void points where new knowledge, events, and truths can break free. How this knowledge translates to the day-to-day activities of a highly functional mathematics classroom is an important area of inquiry, one in which very little work has been done thus far. The concluding chapter in this dissertation offers preliminary guidelines for a new type of pedagogy, termed "pedagogy of the event." Here I will reframe my comments to specifically discuss teachers in the classroom.

den Heyer (2009) explains a Badiouian subject as an ethical human being who after witnessing an event shares his or her capacity for interpreting this event with others in a shared community of innoculators who all believe that there is more to the given situation in which they live than what is represented. For education, the question becomes how such a community can arise and be sustained in a classroom, and what types of conditions can be held in place to make such a community awake? For den

Heyer, the answer lies in curriculum arrangement. Therefore design a curriculum to honor "the truth of human aspiration and dreaming" and nurture affirmative capacities for inventions rather than capacity for despair (ibid. p. 444). The author argues that educators must create a space for students to consider "the possibility of new possibilities" (Ibid. p. 444). den Heyer views the classroom as first and foremost a space where ideology reigns supreme and normative values are upheld. Badiou's "ethics of truth" helps shatter such illusions since rather than honoring societal values or relativism multi-culturalism arguments, Badiou places utmost importance on truths, universally applicable to everyone. For Badiou, "the real question is not difference, but recognizing the same" (ibid. p. 448). Therefore, for den Heyer the work of an educational researcher is to provide a new way of arranging knowledge in order to give a new trajectory for future inspiration and aspiration of human dreaming. Once students have the ability to use their imaginations to ask not only epistemological questions about mathematics, but ontological questions as well, revolutions in how society uses mathematics can occur.

I would like to add to den Heyer's proposal that a teacher must also be aware of the policy landscape in great detail. Arranging of curriculum after all cannot occur without a firm grasp of the discourse in all its complexity. For a teacher working in education today, what my study offers is a way to better understand the situation and how it is working within so that we, as educational researchers and/or professional educators, have the skills and knowledge to combat it much more effectively than radical alternative theories attempt their work from outside the conditions by which they are structures (e.g. transformative pedagogies). In fact, what I am proposing here is a radical optimism for teachers and educational researchers, since I believe that precisely the policies as they exist are precisely where the moments of real radical reforms can take place.

This is contrasted with radical transformative pedagogies that I have discussed in Chapter Three, since those do not take into account the existing infrastructure of educational discourse and policymaking and therefore cannot offer any truth, political or otherwise. Not knowing the state of the situation and possessing the expert knowledge that characterizes it would not only hamper a human being from becoming a Badiouian subject, it might make it impossible. However, for a human begin to become a subject she must bare witness to an event. Such an experience is always contextual and active insofar as it occurs in a particular place, at a particular time, and to a person who is actively engaged in it. Perhaps, this agency of the subject can be interpreted pedagogical, but also methodological. In the former case, a teacher's knowledge of the complex philosophical assumptions inherent in mathematics policy discourses can play a significant role in how he organizes activities in the classroom. In the latter case, a researcher's interest in exploring the complex philosophical assumptions inherent n mathematics policy discourses can influence the methods of analysis she chooses.

4.4. Philosophical Method

In this section, I offer a method, influenced by Badiou, for studying educational policy. The purpose of this method is to provide a philosophical perspective for educational researchers, and especially for educators themselves, to utilize in their own practice so that they 1. Have a more clear sense of the policies that shape their classrooms, and 2. Develop a sense of agency in enacting pedagogical techniques that leave space for the possibility for truth events to occur within the classroom.

Before developing this methodology, several explanations must take precedence. They are Badiou's system for classifying presentation/representation, his foundational axioms of which he gives no proof, and his description of truth procedures.

To explain how I used Badiou's philosophical method in this dissertation, I need to showcase the uniqueness of his method. Unlike Dewey's synthesis or a Hegelian triadic, Badiou sees reality as always a state within a state or a reality within a reality. To better explain this, notice the below chart:

Situation	state of the situation
Presented	represented
Belonging	including
Count-as-one	Second Count

The situation is what exists in our world and the state of the situation is how we understand it or come to represent it. "A situation in which at least one multiple on the edge of the void is presented" (2005a, p. 75). Since in Badiou's ontology there are only multiples and the one is not, we begin with presentation as a count, which makes the infinite pure multiple comprehensible to us. This multiple is said to belong to the situation and be presented. The second count is akin to our reflection about the situation, and this is where the multiple (which is not quantifiable) is counted again and represented as included in the situation. An example of this is a citizen who belongs to the U.S. by birth, is counted in the census for population demographic purposes, yet does not vote or hold any public office or engage in any public activities whatsoever. The citizen can be included and represented if he does vote and/or runs for mayor of his small town, for instance. Within the situations structure and the state of the situations meta-structure, there always exists a void. This is not proved or justified by Badiou, since it is given as a prior as a characteristic of being itself, a concept of which we can have no knowledge of. What we must understand about the void, is like the mathematical concept of the null set, that it is inherent in all situations, universally included, and thereby, a subset of all other sets.

A site is the gathering of all non-presented elements of a situation, but it is the event that will determine if some subject, who remains faithful to it, gathered any elements. There are four kinds of sites in any given situations:

- Normal – presented and represented, include and belong
- Excrescence – represented but not presented, include but not belong
- Singular – presented but not represented, belong but not included
- Historical – at least one eventual site, at the edge of the void

(2005a, p. 188).

A Normal situation as defined by Badiou is the state of the situation. A historical situation is any situation in which newness or change occurs. This change can occur within any of the four truth conditions that Badiou categorized as happening in the realms of love, politics, mathematics, and art. Badiou's most popular examples are the Maoist revolution in China, or Marcel Duchamp's "fountain" that revolutionized what was considered art. In an excrescence situation something is included that does not belong, for example when votes are counted from non-citizens in a political race or poll or when demographics of a particular cultural group include another cultural group that does not affiliate itself with the first. Badiou does not spend too much time discussing this situation, and is much more interested in the singular situation, since for him this type of situation provides the necessary conditions for revolutionary change to occur. A singular situation occurs when something that belongs in the situation is not included or is presented but not represented in the final (second count). For example when a particular demographic group of voters are included as citizens but not included in political polls. Another example is when a cultural group is included as industrial workers in a corporation, but their views and needs are not represented as part of the corporate world.

Badiou's agenda is to understand the conditions by which newness, or as he terms it, an event, takes place. These conditions happen with existing situations that structure our socio-political, cultural, scientific worlds, as well as our personal loving relationships. Given Badiou's ontology of infinite multiplicity in any given presentation, it is impossible for everything to be represented that is presented or all things to be included that which belongs. Standardization wants to deny the multiplicity or the complexity of the situation. The claims, objectives, and perceptive formulas in policy documents are represented as the totality of the situation that is educational policy landscape in the US today. However, there is much more information that is not represented but merely "belongs" within the situation. This minor discrepancy for Badiou would signify that there is a void to which a truth event can emerge.

The empirical study in this dissertation seeks to do exactly that. By exploring the landscape of policy discourse, I am mapping out the state of the situation. This method leaves the situation as such subjective only in the sense that it cannot be completely documented or represented through the policy documents that exist. However, by utilizing Badiou's method of set theory, researchers can investigate the reality that exists before the state of situation has had its "second count." What I will be looking for in the empirical chapter to follow is where there might be a Badiouian "void", which can only be found in a singular situation, which is defined as having at least one element that is presented but not represented, belong but not included. This element, in my analysis, must be a code that stands for either educational objectives (axiological), claims of knowledge (epistemology), and conceptions of mathematics (ontology). Perhaps, it is not one code, but how various codes interact. The final section of the next chapter will illustrate this analysis.

What we must remember through the analysis of the findings is that there is an inherent paradox in policies, since they attempt to explain everything, and prescribe increasingly more detailed actions, curricula, and standards. But in its attempts to do so, it opens more of the void in that it becomes apparent to the policy analysis that there is indeed more complexity to be found and understood, and to the educator in the classroom it becomes apparent when they realize that no amount of planning, assessing, and prior experience, can prepare them for the particulars of the daily life in a classroom. In more Badiouian terms, in every attempt to be coherent, there is an incoherence produced by the void at the heart of the state.

Badiou framed his question this way: “The question is not whether possibilities are possible but is there the possibility for new possibilities?” The difference between these two options is critically important. In the first question—”Are possibilities possible?”—Existing possibilities are found within the frame itself, while in the second—”Are new possibilities possible?”—a restructuring of the very frame of possibilities opens up beyond the closure of the present moment. Badiou’s answer to this second question is an emphatic yes! Badiou’s definition of political activist is one that is a “patient watchmen of the void instructed by the end” (2005a, p. 110).

As an educational researcher, I envision my current role with this dissertation as providing a landscape of the policy discourse as it stands, within the given situation of current U.S. policy reform discourses in mathematics education. The purpose of this landscape is to give teachers and other educational professionals the knowledge of the situation and the conditions by which it is structured so that we may work within the situation to enact change within it. However, I am not calling for revolutionary change as the critical theorists do, nor am I simply refusing to take a position on educations role in our global neoliberal society. More simply, I am advocating for an understanding first of the complexity of the situation before any changes can be envisioned. Additionally, I am hoping such understanding fosters greater agency for teachers that have the great responsibility and joy of enacting top down national policy decisions in their own classrooms. I strongly assert that it is within the classroom itself and the way in which mathematics is discussed and taught where we will have the greatest impact on our socio-political system. Teachers, by reconfiguring the policy recommendations in the classroom in creative ways have the potential of altering the minds of future citizens who will inevitably inherit a numerical world that hopefully will not control them, but rather be re-envisioned by them into something more beautiful than what our present world consists of. This new conception of a teacher becomes increasingly important when considering the pressure the teaching profession is under, especially in mathematics. Teachers often feel this pressure and are constantly being assessed by how well their students perform on standardized test; moreover, their practices and outcomes are analyzed and measured and they are held accountable to their community and for their very jobs. It is my hope that once teachers gain the knowledge of policy documents that the kind of work this dissertation provides, they will feel more than mere facilitators implementing top-down policy reforms in the classroom where they are being judged on their efforts. Rather, teachers will gain a sense of indifference to the policies themselves, seeing them for what they are – multiplicities of the state of the situation to which their vocation of choice has brought them. Instead of being considered with assessments that measure student outcomes, teachers can become passionately aware of the revolutionary potential of events that can happen in their classroom, at any time and to anyone.

Chapter 5: Methods

In this section of the dissertation, I explain how the main empirical findings are described, analyzed, and discussed. I begin with explaining the background on the methodology chosen for this work and the past efforts in education that utilized similar methods. Then, I provide detailed explanation on how the methodology was used for this dissertation. Here, I explain the data points, the coding schema, the analytic constructs, and the analysis process. Next, the findings of the analysis are given in both table and narrative forms. Last, I discuss how the findings fit within the larger policy discourse and what implications the findings may have for mathematics education policy and future reform efforts.

5.1. Content Analysis

The methodology I used for this study is content analysis, which could be classified as a mixed method approach. I used both qualitative and quantitative strategies in the study since I was interested not only in understanding the components of the policy texts as well as gathering numeric frequency of certain categories that I have specified (Kracauer, 1952; Scott, 2004). Qualitative content analysis encourages a deep familiarity with the documents, which can then lead to identification of key themes so as to draw inferences from the textual material (Perakyla, 2005).

I used Hyper Research, a software package for qualitative research, for this process since it allowed coding to go systematically and generated statistics and charts to show the distribution of the codes. *Hyper Research* is a powerful program that not only allowed me to code documents, but to see relationships amongst codes, and to assign multiple codes to any given text (Hesse-Biber, Dupuis, & Kinder, 1991).

Content analysis offers a systematic methodology for this research since it allows a researcher to investigate the assumptions made within policy documents and affords a reflexive window into the cultural patterns, interests, and values a society holds. As a methodology, content analysis can be classified as both quantitative and qualitative, since it incorporates numerical data analysis as well as an interpretative recursive approach to understanding the problematic. Krippendorff (2004) calls content analysis a "scientific tool" that "provides new insights for researchers to understand particular phenomena that informs practical actions" (p. 18). Merten (1991) explains, "content analysis is a method for inquiring into social reality that consists of inferring features of a non-manifest context from features of a manifest text (p. 25). Traditionally, context analysis was interested in studying communication texts to uncover the themes, symbols, and possible meanings embedded in textual data.

Early uses of the methodology focused on political texts for cognitive psychological descriptors that may have influenced how the reader could interpret the text or how the text attempted to influence the judgments and/or perceptions of the reader. Krippendorff classifies contemporary content analysis as an "empirically grounded method, exploratory in process, and predictive or inferential in intent" (p xvii). The modern uses of content analysis methodology range from qualitative approaches that explore in a hermeneutic circle meaning of the text, to quantitative styles that investigate a more nuanced use of symbols and words embedded in textual data.

There has been considerable scholarship utilizing content analysis, or another similar type of discourse/textual analysis, as a tool for uncovering explicit and implicit assumptions embedded in documents or transcriptions. Much of the work has been done outside of education, primarily in media studies and/or communication studies. An exemplary piece is from Hye-Jin, Beom, Thomas, & Hyunjace (2011) that studied anti-smoking websites to understand the messages being propagated by these efforts.

One field within educational studies that seems to frequently utilize content analysis methodology frequently is counseling. Several examples of this are Horton & Hawkins (2010) analysis of doctoral program abstracts to find if the programs in which the candidates were enrolled encouraged intervention research and Smith, Kok-man, & Mityagen (2008) investigation of 78 articles to explore how multi-culturalism was represented in the literature. Another example of content analysis used to examine issues in counselor education comes from Minton & Pease-Carter's (2010) study on the status of crisis preparation. Other areas of content analysis research in education include adult education (e.g. Mulenga, Al-Harthi, & Carr-Chellman, 2006; Saarinen, 2008), cognitive studies (e.g. Lavigne & Lajoie, 2007; Saban, 2009; Yang, 2011) and most recently, virtual worlds such as distance learning environments and blogs (e.g. Feihong & Lockee, 2010; Hou, Chang, Sang's, 2010). An important field of research, gender studies, yields excellent work, such as Taylor's (2009) study of gender stereotypes in children's books and Lee, Fox, & Brown's (2011) work on gender differences in math proficiency. What all these research studies have in common is that they employ the methodology of content analysis as a tool by which to study embedded meaning in textual data that could otherwise be overlooked.

One common data source for content analysis is newspapers or journal articles. This type of work yields important knowledge about how societal norms and research agendas are set. For instance, Walsh & Petty (2007) conducted a ten-year content analysis study on the frequency of particular early education programs discussed in education journals and found that Head Start was predominantly mentioned. Another example is Walsh & Sanchez (2010), who analyzed four elementary journals to see where the funding for research comes from. Newspapers are a particularly excellent source of data, especially for researchers interested in the political dimension of social reform. One such example is Tasdemir's (2011) content analysis of how national newspapers portrayed school curriculum reform over a period of three years. Within science education research, we find the work of Lee, Wu, & Tsu (2009) who studied international journals of science education and D'Agostino et al.'s (2011) analysis of three leading education journals from 1999 to 2008.

Content analysis, as explained above, can be either qualitative or quantitative, or a combination of both. Qualitative content analysis is exemplified by Young & Vrongistinos (2010), who transcribed open-ended responses from Hispanic parents about their perception of their children's education. Garli & Rule (2009) examined poster presentations of math and science lessons that incorporated social justice issues made by student teachers. Acar & Kilie (2011) transcribed semi-structured interviews with teachers and students to analyze the types and conceptual categories of questions asked by each. For a strictly pedagogical objective, Koc, Peker, & Osmanoglia (2009) used content analysis to understand the way in which support was given by master-teachers to student teachers in an online format. Other examples of researchers studying how to enhance pedagogical knowledge was Kong (2010) work comparing reflective notes made by student-teachers, and last, Hou, Chang, Sang's (2010) research on teacher blogs to test knowledge of bloom's taxonomy schema.

Content analysis has been greatly used in researching education policy. This work can be categorized based on the data used to exemplify certain aspects of the policymaking process. The two categories I delineate are curricula documents (e.g. textbooks, standards), which reflect policy decisions at a state or local level and legislative documents (federal, state law, mandates, or initiatives), which reflect national or state policy recommendations and/or initiatives. For the former there are several studies of note. First, Carnine & Jitendra (1997) work on comparing various pedagogical perspectives found in curricular materials helped illuminate how different programs may be inadequate in meeting their stated goals. Camicia (2009) studied the range of civic and cultural perceptions found in curricula in social studies textbooks in an effort to strengthen the instructional material to encompass a more democratic deliberative agency for future citizens. Fede (2006) studied high school textbooks to find the values inherent in mathematics, and found it favored rationalism, control, and openness. LaBelle (2011) studied textbooks to determine the range of teaching models represented. Another example of this type of content analysis is a research study that analyzed 28,000 pages of elementary school mathematics textbooks to see how they changed over the course of a century in the U.S (Baker et. al., 2010). They found many changes over the span and their work is highly informative in understanding the paradigm and values shifts implicated in U.S. mathematics education policy over time. Other than textbook analysis, standards in curriculum are a useful data source for policy analysis in education. Examples of this work are Herbert & Lohrmann's (2011) study of the relationship between instructional strategies of health education curriculum in order to understand if they included strategies for actively engaging students in acquisition of health skills and Tenam-Zemach's (2010) analysis of local and national K-12 science curricula to investigate ecological paradigms.

Content analysis used to study educational legislation can be found with Eyler et al. (2010), who examined trends in state physical education legislation to develop a comprehensive inventory of state physical education legislation. Examined bills from 2001-2007. To study the national education policy in Turkey, Erdogen, Marcinkowski, & Ok's (2009) review of policies and practices for environmental education K-8 from years 1997-2007 provide a strong example. Another example is from Fitzgerald (2011), who analyzed letters-to-the-editor to understand people's perceptions about bilingual education in two states. They found most people were motivated by fiscal concerns.

Specifically in mathematics education policy, there have been several researchers who employed content analysis as their preferred methodology for their research agendas. Higgins & Parsons (2009) studied New Zealand's numeracy policy implementation to find three pedagogical tools that proved useful for gaining knowledge abut elementary mathematics. Brantlinger (2011) compared critical mathematics discourse and traditional as a textual analysis to examine how politically these were incorporated in the curriculum and found that critical mathematics proposed by advocates in the US is problematic in terms of the equity in mathematics education. Lou et al. (2011) studied STEM knowledge of female Taiwanese high school students to explore the effects of problem-based learning strategies on the attitudes of female students towards STEM learning. Data was generated through interviews with forty-eight students. Hopewell, et. al. (2009) focused on STEM field speeches and how they include women and minorities.

5.2. Data Collection

For this study I was specifically was interested in collecting publically accessible documents either explicitly from the U.S. Department of Education or directly tied to them through funding or advocating activities, such as specific standardized test reports or particular policy recommendation reports. In order to capture these documents, I incorporated a recursive strategy for data collection. More specifically, I began with a search in the ed.gov website for policy documents. After these were collected, I expanded my search using the Google search engine with the key words U.S. education policy and mathematics. Next, I considered the NCTM website and NSF for their policy recommendation documents.

Once I began coding, certain documents referenced others, hence the recursive nature of the document retrieval process. I found these documents that were referenced in others and included them if they meet the criteria of being about mathematics generally, and public education in the United States particularly. As these documents were coded, I continuously did a *Google* search for others and looked in the ed.gov website for any new policy statements. The last several documents were found in research articles that referenced certain initiatives or funding agencies that were linked to the governmental policy programs. I retrieved the ones that were relevant within the research articles as well. I stopped the data collection process after I could not find any new documents that fit within my time frame and had to do with mathematics education. This means that I no longer found any documents that discussed anything new and I found similar coding practices throughout the documents. Once the pattern was repetitive and I gathered all the public documents that were referenced in journals, government websites, and NCTM and NSF literature, I knew it was time to finish the collecting process and begin the analysis. In total, I coded thirty-eight documents, ranging in page length from approximately 200 pages to 10 pages (Please refer to Appendix C for the List of Data Points).

Before explaining my analysis process, I would like to mention several important considerations about policy documents themselves. Policy documents are not static entities that exist outside the sociopolitical world out of which they arise. Rather, they are influenced by and created in sociopolitical contexts that are negotiated and agreed by a people within a society that hold a power position which enables them to disseminate their own values, norms, and beliefs onto the masses. “Documents often present and represent the committed positions of groups and individuals on policy issues and therefore can be analyzed to show how particular discourses are dominant, or where tensions in policy reflect struggles between various values” (Sharp & Richardson, 2001, p.199). Understanding policy documents is the way researchers can study the normative assumptions a particular society has on certain issues and disciplines. In the case of this study, views on what mathematics education ought to serve, how it ought to proceed, and what it ought to encompass are all societally held normative assumptions. These assumptions are found in policy documents, since these documents help shape and often reflect the norms held by groups that have the authoritative power to make decisions about what is best for citizens and their children when it comes to their education in mathematics.

Extrapolating the norms a society has on a particular issue is a difficult undertaking. However, analysis of public policy documents provides a method by which researchers can view the rhetoric and discourse surrounding highly political societal issues of great importance, such as mathematics education in the 21st century. Marshall and Rossman (1999) explain that the review of documents is an “unobtrusive method, rich in portraying the values and beliefs of participants in the setting” (p. 116). In other words, documents can be seen as social texts, which “emerge out of, but also produce, particular policy discourses” (Jackmore, & Lander 2005, p. 100). Analysis of policy documents has the potential to expand the research done in policy studies beyond simple implementation advocacy or critique, but to broader areas of discussion about the very purposes of educational policy and how or why such purposes can be used. Please refer to the Appendix 1 for a more complete list of the data points used for this study.

5.3. Coding Procedure

The methodology I used for this study is content analysis as explained in the preceding section of this chapter, which could be classified a mixed method approach. Later, I supplemented content analysis with Badiou’s methodology of using set theory.

In this section, I first discuss the content analysis approach, which comprised most of the coding process and then I explain the addition of the set theory analysis, which occurred at the end of my analysis of the data.

I used both qualitative and quantitative strategies in the study, since I was interested in understanding not only the relationship of claims and assumptions about mathematics and its education found in policy text but I was also interested in gathering numeric frequency of the appearance of these categories. I believe that each type of finding, numerical frequency of categories as well as a qualitative analysis of how these categories fit within the larger structure of the discourse compliments one another. Qualitative content analysis encourages a deep familiarity with the documents, which can then lead to identification of key themes so as to draw inferences from the textual material (Perakyla, 2005). By gathering both quantitative and qualitative results, my analysis of my data was enriched.

My original conviction before starting the analysis is that there should be cohesiveness to the way modern education conceptualizes mathematics, how it is taught, and for what primary purposes its education is believed to be for. From a decade of teaching and research experience in mathematics education, my intuition is that such cohesiveness is not present in the discourses surrounding both alternative approaches to mathematics education and in dominant views as expressed in national policy documents about mathematics education. However, after completing the study, I have found that cohesiveness is more complex that I had originally speculated in policy reform texts. As the findings chapter of this dissertation will explain, the lack of cohesiveness may not be a detriment to policies reform discourses. In fact, the lack of cohesiveness may not be a drawback at all, but rather, it may open the space for the potential for positive consequences for teachers and mathematics learners to explore. Even more radical, the incoherent present in the policy documents is instrumental to Badiou's revolutionary event insofar as multiplicity, which a truth of reality for Badiou, cannot be completely represented. Thus there is always incoherence in policies since they are by their very nature unable to capture the complexity of the multiplicity as such. Such lack of coherence, while viewed as a drawback by policy researchers, is for Badiou a wonderful consequence.

The coding process consisted of a three-fold process. To begin, I coded each document for particular phases that met the analytic constructs I delegated and justified as important. These were explained thoroughly in the beginning of this dissertation in the second part of chapter three. The categories were axiology, epistemology, and ontology. The codes were originally generated by my in-depth study of mathematics education, philosophy of mathematics, and philosophy of education. These three categories, and later three subcategories made a total of nine possible codes. Below is the codebook I created to systematically code each document.

Code Book

Purpose: To create a uniform, rigorous, and systematic coding process for the empirical content analysis section of the dissertation. Objects of research have been identified as axiological, epistemological, and ontological. For each object of research, I will identify the following:

A. Axiological objectives:

Definition: the purposes, objectives, and aims/ends of mathematics education reform policies/initiatives/discourses. This category answers the question of why have specific mathematics reform policies. i.e. what purposes are they for? Why are they important? What good will these reforms have for individual learners? For society at large? For the nation?

Central Question: What are the axiological purposes specified in the textual document?

AU. Utilitarian – other terms used or examples: Industrial Trainer (Ernest, 2000), Technological Pragmatist, or "back to basics". The aim of this axiological reform policy is for economic incentives. i.e. to get a job (individual) or to help make the U.S. more competitive in the global marketplace (national)

Words or phrases: competitive, literacy, workforce, job focus, skill certification, obedience, usefulness, jobs, and economic

Coding Examples:

"America's leadership tomorrow depends on how we educate our students today, especially in science, math, and engineering." (Source – *Uteach Brochure)* This quote illustrates the axiological category of utilitarian because it correlates the nation's future prosperity to individual learning in mathematics.

"Finally, the Council acknowledged that success demands the building of a full and active partnership among the education and business communities and state government, just as it requires action to ensure that high-quality instruction in mathematics and science is an integral part of all secondary, postsecondary and workforce training programs. (Source - *Science and Mathematics a Formula for 21-Century Success*). This quote illustrates the axiological category of utilitarian because it equates education to work or students to a workforce.

AC. Cognitive – Other words used: Humanistic, Enlightenment, or Romantic, modernity, cognitive science, psychology, or liberal arts education.
The axiological objective for this category is strictly for obtaining a high level of knowledge about mathematics and other relative disciplines (science, technology, philosophy). This aim assumes that learning high levels of abstract and contextual understanding of mathematics ought to be the central import for education.

Words or phrases: abstraction, ability, understanding, learning, life long learning

Coding Examples:

“Americans have known that fundamental changes must occur if we want to raise performance levels, prepare young people for lifelong learning and educate all students well.” (Source – *Everybody Counts*).

“The overriding premise of our work is that throughout the grades from pre-K through 8 all students should learn to think mathematically.” (Source – *Adding It Up).* This quote is categorized as cognitive axiological objective since it stresses learning how to think mathematically rather than the end product of getting the right answer or building the correct project such as a bridge or computer program.

“The 21st Century Community Learning Centers program is committed to ensuring that our students have access to high-quality and engaging enrichment activities that can truly support their learning and development.” (Source - *21st Century Community Learning Centers*). This quote illustrates the cognitive as well as democratic axiological objective since it mentions “access” to high-quality learning. Therefore not only is the cognitive objective for learning mathematics stressed but the fact that it is made available to all learners, regardless of their socioeconomic status, gender, or learning difficulties.

AD. Democratic: Other words used: Progressive educators, public educator (Ernest, 2004). This axiological category is primarily interested in political, social objectives that better serve democratic practice, as it is normatively (or radically) defined. There are two ends of the spectrum with this aim: Either it is the critical awareness of the social injustices so prevalent in our society that mathematics education can illuminate (e.g Apple, 2004; Gabbard, 2000). Or it is the fact that mathematics is the “gateway” discipline, so integral in paving the way for a more socially equal polis and therefore is of the utmost importance for minority groups to attain.

Words or phrases: power, politics, social justice, all, equality, minorities, citizens, equitable, informed citizen, gender, access

Coding Example:

“Ensuring equitable distribution of effective teachers and principals” (Source – *Race To The Top*). This is an example of the democratic axiological objective, since it mentions equitable and therefore claims that exemplary mathematics education ought to be made available to all students.

“To me, the lesson is that while there are no silver bullets to chip away at poverty or improve national competitiveness, improving the ranks of teachers is part of the answer. That’s especially true for kids, who often get the weakest teachers. That should be the civil rights scandal of our time” (Source, *UTeach Brochure*). This is an example of democratic axiological objective since it pinpoints the problem with education as poverty.

“Yet, women, in particular, are being left behind in the critical fields of math and science. NMSI is taking steps to bridge that gap” (Source - *NMSI 2011 Annual Report*). This is an example of a democratic axiological objective, since it strives to equal the playing field between man and women in mathematics and science.

“The future prosperity and well-being of our state and its citizens depend on how well we educate our children and youth” (Source - *Science and Math for The 21st Century Success*). This is an excellent example of a democratic and utilitarian axiological category since it correlates prosperity for the nation with the importance of educating our citizens. The key is equating of “citizen” to “student” and “education” and “prosperity for the state.”

E. Epistemological claims: The theoretical claims to how mathematical knowledge can be learned, cognitively, intuitively, and through specific pedagogical teaching techniques/processes. This category is about knowledge, what mathematical knowledge is, and how it can be learned, how it should be taught, and how the learning of it can be assessed.

Central Question: What are the epistemological claims discussed or alluded to in the document with regard to teaching and learning mathematics?

ET. Traditional – This subcategory claims that mathematical knowledge is vitally important, static, and scientifically defined and learned through authoritative practices. In addition, the traditional epistemological view assumes that knowledge exists outside the learner, that students are blank slates, that memorizing (root learning) and “drill and kill” pedagogical practices are beneficial for learning mathematics. Assessment can be made by quantifiable tests that are given to the learner and measured by an outside source such as a testing service or teacher (Cobb et al, 1992).

Words or phrases used: standard, well-defined, assessment, valid, content knowledge

Coding Examples:

“Assessment should be an integral part of teaching, and must align with curricular objectives” (Source – *Everybody Counts*). This quote illustrates the traditional epistemological claim, since it assumes there are exterior objectives that can be known prior to the teaching and learning process.

“A strong focus on acquiring deep content knowledge in math, science, computer science, and engineering, in addition to research-based teaching strategies focusing on teaching and learning math and science” (Source - *UTeach Brochure*). This quote illustrates the traditional epistemological claim, since it believes quantitative (this is explicit in other places in this particular document) research is the "gold standard" of research in education. This type of research assumes knowledge is outside the cultural/social process and thus something that can be known outside the teaching/learning active process.

EC. Constructivist – This epistemological category is child-centered and believes mathematical learning must be cultural and socially developed, that hands-on authentic learning is the best pedagogical practices, and that knowledge is constructed via the learner (e.g. D'Ambrosio, 2001; Eglash, 2002; Frankenstein, 1983).

Words or phrases used: build knowledge, real-life, authentic, hands-on, cooperative, constructed, active, learner-centered

Coding Examples

"No one can teach mathematics; effective teachers help students to learn mathematics through the construction of understanding. This happens when students work in groups, engage in discussion, make presentations, and take charge of their own learning." (Source – *Everybody Counts*). This is an excellent example of the constructivist epistemological claim since it specifies the learner as the one who constructs his/her own understanding and that such understanding happens through specific activities such as the ones mentioned and not by the traditional "rote" learning of past pedagogical techniques.

"Learning mathematics is an active process. 'Knowing' mathematics means 'doing' mathematics" (Source - *NCTM Curriculum and Standards*). This is an example of the constructivist epistemological claim, since it depicts learning mathematics as active, therefore not something outside the learner or knowledge that is static and can be given in full to the learner from the knowledge source such as a teacher.

EF. Transformative – This epistemological category believes knowledge is equal to power and that be teaching this axiom in mathematics education is crucial for developing the critical consciousness Freire and others have strived for (e.g. Gutstein, 2006; Skovsmose 1994).

Words or phrases: transformative, critical, awareness, power, empower

Coding Examples:

"Mathematics empowers us to better understand the information world in which we live." (Source - *Everybody Counts*). This is an example of the transformative epistemological claim since it equates mathematical knowledge with power and sees that the more mathematics one has understood, the better position one has in understanding the world.

“Mastering the rigorous coursework is transformative. Students who excel in AP coursework are three times more likely to graduate from college“ (Source - *NCMI*). This is an example of the transformative epistemological claim since it not only uses the word “transformative,” perhaps superficially, it also claims that mathematical knowledge empowers the student to finish college and therefore be in a more powerful position in adulthood.

O. Ontological assumptions: The underlying assumptions about the nature of mathematical objects and procedures and how these do or do not hold truths or not about the way the world operates or the relations that exist in our social/cultural/material reality.

Central Question: What are the ontological assumptions inherent in the discourse about the very conception of what is mathematics?

OA. Absolutism – This subcategory assumes that math identities are found in natural phenomena, outside human cultural sphere. Numbers are real in the sense that they correctly signify the world around us and such a world exists regardless of human intervention (Devlin, 2000; Dehaene, 1997; Rowlands & Carson, 2002; Popkewitz, 2004)

Words or phrases used: discovery, real, foundational,

Coding Examples:

“An intuitive sense of the magnitudes of small whole numbers is evident even among most 5-year-olds who can, for example, accurately judge which of two single digits is larger” (Source – *National Advisor Panel*). This is a good example of the absolutist ontological position since, it assumes numbers are stable truths that exist outside the human child and moreover that this child has an intuitive, perhaps biological, sense of such static entities.

“First, numbers and operations are abstractions—ideas based on experience but independent of any particular experience” (Source - *Adding It Up*). This is a perfect example of the absolutist ontological assumption that numbers are independent of human cultural or social constructions.

OF. Fallibilistic – This subcategory assumes that math identities or concepts are found in cultural, social, political realms and do not exist independently without humans (Kilpatrick, 2001; Hersh, 1993; van Glasersfeld, 1991).

Words or phrases: no correct answer, no authority,

Coding examples:

"Mathematics instruction must not reinforce the idea that all problems have one correct answer or leave the impression that mathematical ideas are the product of authority." (Source – *Everybody Counts*). This is a good example of the fallibilistic ontological category because it says that mathematical problems may have more than one answer and that not one given person or culture has the right answer or correct mathematical understanding.

"Mathematics is invented, and it is discovered as well." (Source – *Adding It Up*). I classified this as a fallibilistic ontological assumption since the document made a point of saying that mathematics is invented, which is striking given the typical discourse of mathematics education reform.

OE. Aesthetic – These subcategories assume that math identities are inherently beautiful, profound, interrelated, and pattern forming, and elicit an emotional response in their observers. (Resnik, 2000; Shapiro, 1997).

Words and phrases used: beautiful, patterns, curiosity, inspire, art, love of

Coding example:

"You don't want them to go through rote memorization where they are not really learning anything. I want them to learn the art of math, and you get that through hands-on work." (Source –*Uteach Brochure*). This quote was classified as constructivist epistemology due to the hands-on-work reference and the aesthetic ontology since it mentions art of math.

"Mathematics is also an intellectual achievement of great sophistication and beauty that epitomizes the power of deductive reasoning." (Source – *Adding It Up*). This quote characterizes the aesthetic ontological assumption, since it equates mathematics and beauty together.

The second round of coding paid specific attention to word choice and grammatical usage. I found certain words/phrases repeated in the documents and I counted these words within the subcategories. The particular words I was interested in coding for arose organically through a grounded approach as depicted by Krippendorff. At this time, I speculated that the key words and/or phrases would range from the following three categories with these possible words:

Category	**word/phrase**
Ontological	reality, social, practical, beautiful, organic, faulty, cultural
Epistemological	construct, memorize, drill, invent, discover, meaningful
Axiological	competition, technology, literate, aesthetic, skills,

In addition to coding each document for the 9 different categories (three main and three within these called subcategories), I recorded words and/or phrases that seemed to recur often. A simple tally system using paper and pencil was on hand during the computerized coding process. In this way, I was able to keep track of words and phrases that I noticed often and their frequency. Once the coding procedure was done, I went back to the tally sheet and reviewed the ten most recurring words/phrases. Then I did a tally again using the computer's "finder" function of the folder that contained all the documents. I recorded this number as well as two examples of the context in which the words/phrases appeared. These findings are discussed in the section B of chapter six.

The third round of coding was interested in understanding relationships between sub categories, as they exist within each policy document. I used tables and an experimental methodology of mathematics axiomatic set theory to understand the relationship among the three research categories. Here, a simplistic version of set theory, which only utilized some basic language and operations, was used to try and theorize where a Badiouian event might occur, or for Badiou's concerns, where the void in policy documents exist, since that is precisely where an event has the potentiality to be found or witnessed by a subject.

Chapter 6: Findings

This chapter offers detailed descriptive findings from the empirical content analysis study conducted for this dissertation. The findings are presented amongst four tables, each exhibiting in a different way I made sense of the data. I offer extensive mathematical analysis not because I feel it is valid and objective, but to offer a rich description of the data so that the reader, as well as the researcher, can interpret the findings in a thoughtful, knowledgeable way. The first section (A) gives a overall picture of the findings by using tables and graphs. The second section (B) offers more detailed examples of the words and/or phrases that most commonly appear in the documents. Section (C) delves further into the interrelations of the codes and how they appear in each document. And Section (D) is the experimental Badiouian set theory method that strives to understand what elements are present in the policy documents but not included.

6.1. Overview of Findings

The total data points (policy documents) that completed the survey of available public documents about U.S. mathematics education were 38. After completing the coding process, the study yielded a total of one thousand, one hundred and twenty codes. As expected, the codes in the axiological category were most prevalent. This outcome was expected because I was dealing with policy documents, which are inherently about prescribing objectives education ought to meet. While all three subcategories of axiology had a large presence in the coding, the utilitarian axiological claim was most prevalent with a total of 240 coding instances. Very closely behind was the democratic axiological category, with a total of 209 instances in the documents. The cognitive axiological claim came up 136 times. However, axiology was not the most prevalent of the codes present in the documents since the epistemological code of traditional came up 259 times, beating the most popular code. The next most popular epistemological class was constructivist with 116 coding instances, followed by transformative with only 12 coding instances. As for the ontological codes, these came up relatively less than the other categories, but this was expected due to the nature of rhetoric in policy documents. The code for absolutist came up 87 times, which is comparable with the axiological category of cognitive (136 instances) and the epistemological category of constructivists (116 instances). Interestingly, the aesthetic ontological category showed up 57 times in the documents and the fallibilistic category in ontology only came up 7 times. Although all the codes had a minimum of zero, which means that there was at least one document in the data set that did not include any given code, they all had different maximum values, which specify the maximum amount of times a code appeared in the data set. Please see Table 1 below for a bar graph depicting the distribution of the codes overall in the policy documents.

6.1.1. Table 1: Total Coding Distribution

Code	Total	Min	Max	Mean	Std. Dev.
Axiology - Cognitive	**136**	**0**	**136**	**34**	**61.514**
Axiology - Democratic	**209**	**0**	**209**	**52.25**	**100.54**
Axiology - Utilitarian	**240**	**0**	**240**	**60**	**120**
Epistemology - Constructivist	**116**	**0**	**116**	**29**	**58**
Epistemology - Traditional	**259**	**0**	**259**	**64.75**	**128.834**
Epistemology - Transformative	**12**	**0**	**12**	**3**	**6**
Ontology - Absolutist	**87**	**0**	**87**	**21.75**	**43.5**
Ontology - Aesthetic	**57**	**0**	**57**	**14.25**	**28.5**
Ontology - Fallibilistic	**7**	**0**	**7**	**1.75**	**3.5**

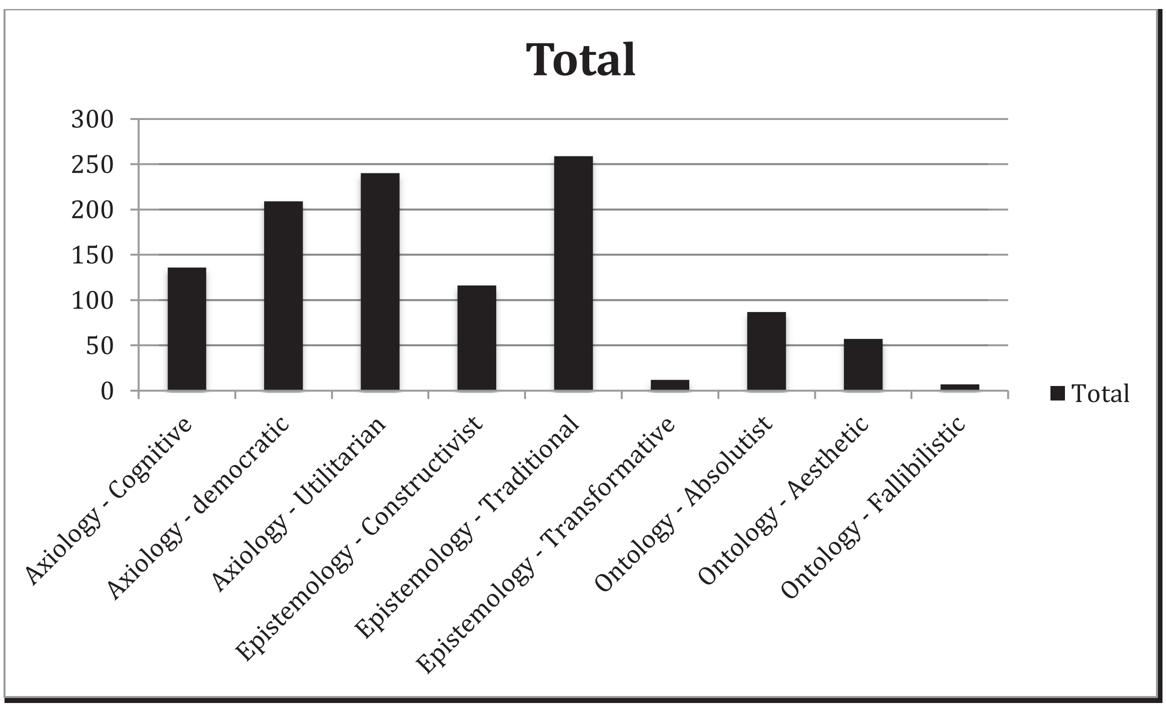
At first glance it seems like the two most prominent categories were epistemology-traditional and axiology-utilitarian. However, when combining the subcategories, we get axiology totaling 585 and epistemology with 387 codes. This makes the highest code of epistemology traditional even more apparent and the axiology code utilitarian less so, since relatively speaking the utilitarian code did not add the majority of codes to the axiology category but was mixed with the democratic and cognitive codes. The epistemology code for constructivist (116) and transformative (12) did not make as much of a contribution to the overall epistemology coding category. However, it is interesting to note that the code for epistemology constructivist, 116, did appear slightly less than the code for axiology cognitive, 136. The axiology codes of democracy and utilitarian were relatively strong since the former had 52 as a mean and the latter had 60.

The epistemology codes took up a large percentage of the total codes, perhaps more than expected, since policies are mostly written for overall objectives they wish to achieve. Not surprisingly, the traditional epistemology category dominated, with a mean of 64.75. Next was the constructivist category, which had a 29 mean code frequency. Last, the transformative epistemology category only had an average of 3. These are not surprising findings since the literature on mathematics education policy dictated that standardization, content knowledge, and expertise were essential to knowledge and ought to influence the way in which mathematics education is taught in the U.S.

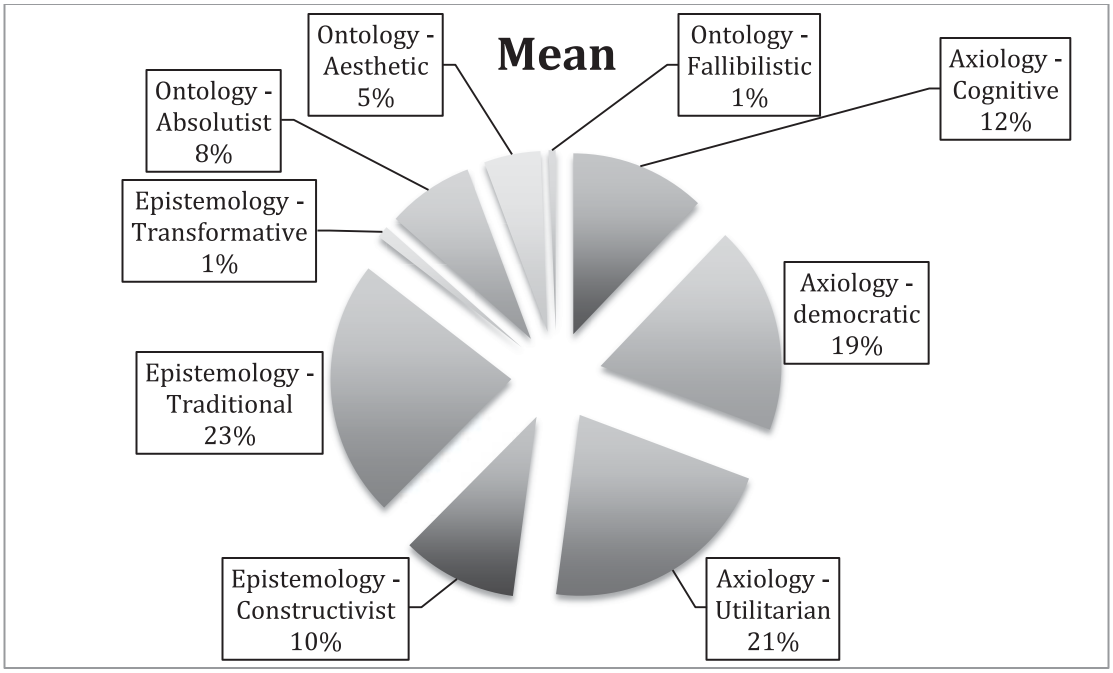
The ontological codes were relatively small in comparison to the other coding categories, but again this is to be expected. However, it was still encouraging to find ontological reference in the policy discourse. I was surprised to find very few codes for fallibilist ontological category and as much aesthetic codes as I found in the documents. Even though the absolutist subcategory was predominant at 87 codes, the aesthetic subcategory did fare comparably at 57 total codes. The average of these two codes is even more similar with the former scoring 21.75 as a mean and the latter 14.25 on average.

Below, Table 2 and Table 3 give a more visual display of the distribution of codes in the policy documents.

6.1.2. Table 2: Comparison of Total Codes



6.1.3. Table 3: Comparison of Average Distribution of Codes



The Bar Graph in Table 2 shows the frequency of codes in relation to one another and the Pie graph depicts the percentages of average codes in relation to the total codes present in the documents. The epistemology category of transformative is similar to the ontological category of fallibilistic, both at one percent of the total codes given. The two ontological categories of absolutism and aesthetic are similar in comparison to the remaining coding categories. The epistemological category of constructivism at ten percent of the codes is similar to the axiological category of cognitive, which has twelve percent. The remaining, more dominant categories have relatively equal coding percentages, at twenty-one percent which is axiology-utilitarian, twenty-three percent for epistemology-traditional, and nineteen percent for axiology-democracy.

6.2. Numerical Findings

This section of the chapter presents the quantitative findings in greater detail by providing examples of the most prevalent words and/or phrases in the documents analyzed and how many times these words/phrases occurred in the data set. The list below shows the most used words beginning from the most common word and provides two examples. I generated this list by a search function using only the documents of the data set. The number by the word depicts the amount of times this word occurred in the documents, such that if it occurred more than once in any given data point, it is only counted once. Therefore, the number signifies how many policy documents out of the total of thirty-eight have the word in it. After the examples, I provide some context and my own interpretation for why these words were the most prevalent in the data set.

Teachers – 38 or 100%
Examples:

- "Twenty-four investments, with a total budget of $312 million, have the primary goal of improving teacher effectiveness, with most of that funding going to **teacher** professional development" (*Coordinating STEM Federal Policy*, p. 20).
- "Our nation cannot expect to train our children for the high-skilled jobs of today, or for the opportunities of the future, without investments in a world-class education system. And America cannot build a world-class education system without **teachers** in our classrooms" (*Education and the American Jobs Act*, p. 9).

The fact that "teachers" is the most popular word in the policy documents of this study is not surprising. Given the plethora of contexts and the great emphasis with which the word "teachers" showed up in the documents should spur much future research in education. Teachers are always a big focus in policy reforms because of their pivotal role in the implementation process. However, the way the word "teachers" showed up in this data set was very interesting and will be discussed in much greater detail in the discussion chapter succeeding this one. For now, it suffices to say that teachers are seen as a crucial component for success in mathematics education, and thus ought to be a serious focus of policy reform efforts, especially in funding opportunities.

Research – 38 or 100%

Examples:

- "The program provides three years of support to approximately 1,000 graduate students annually in STEM disciplines who are pursuing **research**-based master's and doctoral degrees, with additional focus on women in engineering and computer and information sciences" (*CRS*, p. 20).
- "A balanced r**esearch** portfolio in all fields of science and engineering research is critical to US prosperity" (*Rising Above the Storm*, p. 8).

It is not surprising that "research" is a prevalent word to appear in this data set, which focuses on policy reform efforts in mathematics education. What message to take away from this fact is that research, specifically when driven by a quantitative experimental design methodology, is seen as the "gold-standard" for justifying policy decisions. What I find interesting here is that a certain type of ontological conception of mathematics drives the research that is being used to make decisions on the very nature of how best to teach mathematics to youngsters. If this was a science experiment, it would be incredibly biased, since the conditions themselves are set up to only calculate one affect. Even more alarming is that this affect that is thought to be calculated was itself used to calculate itself; this presents a circular argument that simply cannot be validated. Researchers who hold a Platonic or realist ontological view of numbers do not question the results obtained from quantifying phenomenon. However, Structuralists like Resnik and Shapiro who fall within an aesthetic ontological conception of numbers would only be interested in the pattern or relationship the quantifiable phenomenon they study exhibits. For example the results of a research study that finds a significant positive correlation with students who have had a particular intervention, such as Singapore mathematics curriculum versus their counterparts who studied mathematics in their regular classrooms with the traditional materials. A researcher with an ontological realist stance on numbers would find these results reliable enough to advocate for policy reforms that incorporated the Singapore mathematics curriculum. On the other hand, a researcher with a fallibillistic or aesthetic ontological disposition towards numbers, would question the reliability of the findings and wonder what other variables played a role in the results but were not studied or counted, such as cultural and social indicators. All of this aside, the point to take away from the prevalence of the word research in the data set is that mathematics is not only the focus of much of the education policy discourse, but also the means by which the policies are rationalized. This assertion of expertise is embodied in mathematics education. “Mathematical formulas are consecrated as models of truth for decision-making in daily life” (Popkewitz, p 21). Numbers, therefore, regardless of how much we choose to avoid it, assume an ontological status in the way in which they are utilized in policies, in research, and in our very lives. This idea becomes even more important if we agree with the critical theorists underlying argument that the socioeconomic system that our society is governed by is inherently flawed and unjust. While I may not agree with the critical mathematics pedagogies methods for solving these injustices, I do believe a peaceful revolution that helps move our society towards a more ethically just world should always be an important objective of education.

The alternative perspective that I hope this study generates is that a social revolution must incorporate a change in how we ontologically understand mathematics.

Assessment – 35 or 92%
Examples:

- "Designers of curricula, **assessments**, and professional development should all attend to the need to connect the mathematical practices to mathematical content in mathematics instruction" (*Common Core Standards*, p 8).
- *"*Improving **assessments.** The proposal will invest in the development of improved assessments, including those in the STEM subjects. Improvement will focus on the measurement of students' growth and their mastery of higher- order skills. These new assessments also will measure students' complex problem-solving and analytical skills" (*Supporting Stem*, p. 3).

Discourse on assessment was not surprising given Obama's Race to the Top initiative centering on accountability of policy at a state and district level. For me, as I explained in the second part of Chapter 2, our ontological conception of mathematics is the foundation by which we even have the capacity to assess and find any meaning in a numerical value that could describe the success of failure of any policy implementation.

Every – 34 or 89%
Examples:

- "We call for changes in the ways that mathematics and science teachers are recruited, prepared, retained and developed throughout their careers, with the purpose being to ensure that **every** Ohio student has teachers who know their subjects and how to teach them, as well as teachers who care about their students and are committed to their success" (*Science and Mathematics A Formula for 21st Century Success*, p. 7).
- "Providing a high-quality education for all children is critical to America's economic future. Our nation's economic competitiveness and the path to the American Dream depend on providing every child with an education that will enable them to succeed in a global economy that is predicated on knowledge and innovation. President Obama is committed to providing **every** child access to a complete and competitive education, from cradle through career" (*American Recovery Act*, p. 11).

The word "every" is synonymous to the word "all" in the way these words are both used in the policy documents. "All" is used to distinguish an equitable relationship between how resources and to whom they are allocated. "Every" is most often used in the same way, yet sometimes it is also used to describe more abstract equal distributions such as classroom spaces and competent teachers. When noticing the word "every" in policy documents within this data set, I made note of their connection to the axiological category of democracy. This makes sense since democratic objectives often rests upon a shallow conception of equality for all. More on this discussion will follow in the axiological section of the consecutive chapter.

Compete – 34 or 89%

Examples:

- "For students to **compete** in the 21st-century global economy, knowledge of and proficiency in mathematics are critical" (*Foundation for Success*, p. 2).
- "A generation ago, we led all nations in college completion, but today, 10 countries have passed us. It is not that their students are smarter than ours. It is that these countries are being smarter about how to educate their students. And the countries that out-educate us today will out-**compete** us tomorrow" (*Blueprint*, p. 5).

As discussed in the beginning of this dissertation, competition is integral to the ends of mathematics education policy. This is evident by a simple read through of STEM policies and in nationally syndicated newspaper reports on mathematics education. What I was interested in understanding was how the concept of competition is used to justify reform efforts in education. More specifically, how mathematics education is valued as a means towards a utilitarian ends, both for the individual citizen looking for a job in an increasingly competitive market and for the nation in an increasingly global economy.

Workforce – 34 or 89%

Examples:

- "The TAP goal of 400,000 U.S. STEM graduates with bachelor's degrees by 2015, while ambitious, is necessary to meet future **workforce** demands and the global competitiveness challenge" (*Tapping American's Potential,* p. 6).

- The America COMPETES Act (P.L. 110-69) addresses concerns regarding the S&T **workforce** and STEM education, and the 111th Congress is debating funding for the programs authorized within it. Policymaker discussions tend to focus on three issues: demographic trends and the future S&T talent pool, the current S&T workforce and changing workforce needs, and the influence of foreign S&T students and workers on the U.S. S&T workforce" (*U.S. Science and Technology Workforce,* p. 2).

As apparent through the analysis of the policy documents and the literature on mathematics education policy in the U.S., the idea of educating citizens for the workforce has been an important educational objective for decades. In fact, the STEM initiative explicitly discusses the need for a stronger workforce that can meet the challenges for both individual employment and national economic security.

Citizen – 30 or 79%

Examples:

- "Reasoning statistically is essential to being an informed **citizen** and consumer. The Data Analysis and Probability Standard calls for students to formulate questions and collect, organize, and display relevant data to answer these questions" (*NCTM Executive Summary*, p. 4).
- "Enrollment of U.S. **citizens** in graduate science and engineering programs has not kept pace with that of foreign students in those programs" (*The U.S. Science and Technology Workforce*, p. 15).

The word "citizen" is ambiguous in the policy discourses. On one hand it stands for a future democratic citizen that has the rights and potentials to live out their lives in "the American Dream". However, on the other hand, a citizen depicts a worker, a consumer, a human capital that is viewed mostly as a means to an economic end. This distinction sets up an interesting dichotomy between democratic objectives on one hand and utilitarian on the other. It is quite fascinating that these two axiological claims both seem to be subsumed together in the policy documents, at least in this data set focusing on mathematics education reforms. I discuss this in greater detail and offer more examples in the discussion chapter ahead.

Innovation – 29 or 76%
Examples:

- "Providing a high-quality education for all children is critical to America's economic future. Our nation's economic competitiveness and the path to the American Dream depend on providing every child with an education that will enable them to succeed in a global economy that is predicated on knowledge and **innovation**" (*American Recovery Act*, p. 49).
- "The proposal promotes innovation—creating and scaling- up effective practices to help students succeed. In the president's fiscal year 2011 budget, $150 million of the Investing in **Innovation** fund will be focused on STEM projects" (*Supporting STEM*, p. 2).

Innovation is often correlated to completion in policy discourses since it is the U.S.'s ability to innovate that is seen as tied to its ability to compete economically worldwide. Knowledge is tied to innovation in an important way, since knowledge of mathematics is a prerequisite to the ability to innovate. Knowledge of mathematics, of course, is believed to be a necessity and therefore a foundation of national as well as individual economic success. This idea ties into the language of mathematics literacy, which states that a person's conceptual understanding of mathematics is directly tied to their future ability to be a worker in the 21st century and a critical fully engaged democratic citizen of the U.S.

Literacy – 28 or 74%
Examples:

- "The content and processes emphasized also reflect society's needs for mathematical **literacy**, past practice in mathematics education, and the values and expectations held by teachers, mathematics educators, mathematicians, and the general public" (*NCTM Executive Summary*, p. 1).
- "Average scores of 15-year-old students on combined science literacy scale and mathematics **literacy** scale, by the Organization for Economic Co-operation and Development (OECD) jurisdiction, 2006 " (*Tapping American's Potential*, p. 11).

"Literacy" is a difficult word to define and it is ambiguous in the policy documents that I coded as well. I believe this is an important word for further research since it ties directly to axiological objectives policies are written to serve. My concern has been throughout this study to show how there are indeed different axiological objectives made and that such claims lead to different relationships between epistemological claims about teaching and learning mathematics, as well as ontological assumptions about what mathematics is all about. While policymakers use the phrase mathematical literacy often in their discourse on school reform in mathematics, I would like to highlight here that literacy might mean very different things depending on the overall objectives one may have in terms of a fulfilling life. This relates to citizenship and competition since to be a "good" citizen, one is expected to know how to keep a job, balance a checkbook, perhaps buy a home or at least have a car loan. All these activities involve a certain degree of mathematical "literacy". Further, it is argued that getting and keeping a job in today's capitalistic free market world, one must have mathematical "literacy," since we are being told such skills are essential for competition not only with our fellow American citizens, but also with people all over the world.

Accountability – 26 or 68%
Examples:

- "States will be allowed to incorporate science and subjects in addition to English language arts and mathematics in their **accountability** systems" (*Supporting STEM*, p. 3).
- "The Director shall develop an evaluation and **accountability** plan for the activities funded under this section that measures the impact of the activities" (America Competes Act, p. 16).

Please refer to the assessment commentary

Active – 26 or 68%

Examples:

- "Students must learn mathematics with understanding, **actively** building new knowledge from experience and previous knowledge" (*NCTM Executive Summary*, p. 15).
- "As researchers, university educators, teachers, and policymakers work to improve mathematical learning and instruction, they must work toward ensuring that all students, both throughout the United States and around the world, have access to high-quality mathematics, including technology that helps all to become **active** learners and participants in the global community" (*An International Perspective on Mathematics Education*, p. 40).

Popkewitz (2004) writes that "knowing" mathematics, according to the NCTM's Curriculum and Evaluation Standards for School Mathematics, is "doing" mathematics (p. 7). This focus on process and doing marks a distinction between the processes of discovery and the reconstructed logic of mathematics. The reconstructed logic emphasizes the formal, deductive procedure of justification that occurs as an end product of inquiry. It systematizes conclusions so that others can test the results, such as methodological discussions of empirical research found in journals. However, reformed mathematics education strives to focus on the processes of discovery in mathematics, not its reconstructed logic.

Partnerships – 22 or 58%

Examples:

- ***"Enhancing partnerships***. The proposal supports partnerships between districts and university mathematics and science departments, STEM-focused businesses, and other outside partners with STEM expertise to advance teaching, learning, and leading in STEM subject areas" (*Supporting STEM*, p. 2).
- "Yet, today's business-education **partnerships** are increasingly built on a recognition that cooperation can help businesses meet both immediate and long-term needs, and that the ultimate beneficiaries of these alliances are the students for whom collaboration means improved career opportunities" (*Science and Mathematics a Formula for 21st Century Success*, p. 21).

The importance of partnerships elicits ideas of cooperation and community. These are viewed as essential skills for the 21st century. This belief has influenced pedagogical techniques greatly, calling for more group work and cooperative assignments. It has also influenced the professional lives of teachers, since in today's climate it is imperative that teachers learn from each other and share their skills and expertise. While there is little to critique here, I do want to mention that this belief in partnerships fits well with the constructivists approaches to teaching mathematics often hands-on authentic real life problem solving is done in a group like setting. There is much research investigating the benefits and shortcomings of this approach, particularly with gifted and struggling mathematics learners, but delving into this literature is not the focus of this dissertation.

Patterns – 21 or 55%

Examples:

- "People who reason and think analytically tend to note **patterns**, structure, or regularities in both real-world and mathematical situations. They ask if those **patterns** are accidental or if they occur for a reason" (*NCTM Executive Summary*, p. 4).
- "Explain **patterns** in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10" (*Common Core Standards*, p. 35).

The difference in the ways in which "patterns" is used here is slight, but an important distinction. What I find interesting is that "patterns" comes up much more often in NCTM documents than in The Common Core. This seems odd, since both organizations are concerned with the quality of teaching and learning in mathematics, and both seem to advocate, at least superficially, inquiry model child-centered active learning techniques. As a researcher expecting policy documents to be mostly about utilitarian axiological objectives, I must say I was confused on first with the frequency by which this word turned up in the coding process, but after all, that is the point of content analysis in showing the researcher what is actually in the documents, rather than what he/she might have originally, based on their own biases, believed was there.

Power – 20 or 53%
Examples:

- "The Geometry Standard takes a broader view of the **power** of geometry by calling on students to analyze characteristics of geometric shapes and make mathematical arguments about the geometric relationship, as well as to use visualization, spatial reasoning, and geometric modeling to solve problems" (*NCTM Executive Summary*, p. 3).
- "Mathematical reasoning and proof offer **power**ful ways of developing and expressing insights about a wide range of phenomena" (IBID, p. 4).

Again, the common core only discussed power in terms of mathematics (i.e. the power of ten). I would like to call attention to the difference in the conception of power in the policy documents versus the critical mathematics pedagogies. In the policy documents, power is depicted as solely positive and something that is gained through mathematics literacy. In critical theory, power is something outside literacy and can only be uncovered by utilizing mathematics. Perhaps there is as much difference in the way power is defined. This is another avenue for future research, but due to the focus for this dissertation cannot be further analyzed here.

Creative – 13 or 34%
Examples:

- "Real-world situations are not organized and labeled for analysis; formulating tractable models, representing such models, and analyzing them is appropriately a **creative** process" (*Common Core Standards*, p. 72).
- "Are assignments or projects **creative** and tied to real-life situations or your child's interests?" (*A Parent's Guide,* p. 5).

Again, I must bring up the aesthetic ontological category of mathematics and relate it to the prominence of the word creative in the policy documents. I believe the use of this word does point towards a budding belief that mathematical inquiry ought to have a creative element and such an element is intrinsic to the discipline itself and therefore would aid the learning process. Although 34% does not seem like a large finding, it regard to the data set, I believe this is significant since it illustrates that the dialogue about how to reform mathematics education is interested in an aesthetic perspective.

6.3. Inter-relationship of Codes

This section of the findings helps to answer research question number two: are the discourses about mathematics education in policy documents coherent? Although I speculate if coherency is a positive or negative trait in policy and if it is a constant or not, the way that I explored these questions was to first map out the codes as they appear in each document. This map allowed me to see the entire structure of the data and how the codes interrelated to one another. To investigate the coherence of the policy documents, the table below enabled me to see how axiology, epistemology, and ontology are related to one another. The codes that appear together in a document should appear to be coherent within all the data set. Is this true? I would expect, given the nature of policy documents about STEM, that the codes would be centered on axiology utilitarian and traditional epistemology. However, what I noticed was that the codes were widespread. All three of the axiological codes were present and correlated with both epistemology tradition and constructivist; even though the former was more dominant, constructivist epistemology came up more than expected given the high pressure of standardized testing.

6.3.1. Table 4: Distribution of Codes per Document

This table is a detailed look into each policy document and the codes found in them. The documents are listed and each main category (axiology, epistemology, ontology) is broken up in their subcategories. Please refer to the codebook in Chapter 5 for the code name. For instance, AU means axiology utilitarian and ET means epistemology traditional. The numbers in each column stand for the number of times each particular code appeared in each particular document. For example, the code for axiology cognitive appeared in the 21st century community centers two times. The final column shows the total number of codes found in each document. I added this column to give reference to the other numbers, since as I have already proclaimed, I think Resnik's ontological view of numbers is the most sound; therefore, since numbers to me are always relational, in my research I always attempt to provide reference to other ways numbers appear amongst each other. This is proportional reasoning as well since a document that has only four total codes, all of which are axiological cognitive, says something very different than a document that has four codes of axiological cognitive but has forty codes in all.

	Axiological			**Epistemological**			**Ontological**			**Total in Document**
Document Name	**AU**	**AC**	**AD**	**ET**	**EC**	**EF**	**OA**	**OF**	**OE**	
21st Century Community Learning Centers	0	2	2	0	0	0	0	0	0	4
Blueprint For Reform	5	6	28	5	0	1	0	0	0	45
Achieving the Common Core	0	7	1	1	0	0	1	0	1	11
Adding it Up	5	1	5	5	8	0	5	3	2	34

America Competes Act	7	6	4	4	0	0	0	0	0	21
American Competitiveness Initiative	16	5	10	14	0	1	0	0	0	46
An International Perspective on Mathematics	1	2	2	2	2	1	1	1	3	15
A Parent Guide: Multiply your child’s success	2	1	0	1	0	0	0	0	2	6
Before It's Too Late	13	3	7	5	3	0	4	0	0	35
Coordinating Federal State Policy	13	3	13	1	0	0	0	0	0	30
Counting on Excellence	4	3	2	2	0	0	1	0	0	12
CRS Report 2006	2	0	3	1	1	0	0	0	0	7
CRS Report 2008	2	0	0	0	0	0	0	0	0	2
Common Core Standards	0	11	0	46	46	0	42	0	31	176
Curriculum and Evaluation Standards (NCTM)	2	6	7	2	12	4	0	0	4	37
Defining a 21st Century Education	9	7	0	2	0	0	2	0	5	25
Education and the American Jobs Act	4	1	1	0	0	0	0	0	0	6
Everybody Counts	1	3	7	1	6	3	1	1	1	24
Executive Summary: Principles and Standards for School Mathematics (NCTM)	3	3	0	0	2	0	0	0	2	10
Gender Differences	0	0	3	0	0	0	0	0	0	3
Highlights From PISA Results	1	1	0	0	0	1	0	0	0	3
Math Teachers: The Nation Builders of the 21st Century	9	6	3	2	0	0	1	0	0	21
Mathematics and Science Partnerships	3	4	4	10	20		3	1	1	46
NCLB a Desktop Reference	0	2	5	7	0	0	0	0	0	14

NCLB Math and Science Partnership Part B	0	2	0	2	0	0	0	0	0	4
NMSI 2011 Annual Report	10	6	7	3	0	1	0	0	0	27
Race to the Top Program Executive Summary	2	9	19	9	0	0	0	0	0	39
Report to the President Prepare and Inspire	5	1	4	2	1	0	0	0	1	14
Rising Above the Gathering Storm	6	0	0	0	0	0	0	0	0	6
Science and Mathematics Education Policy White Paper	3	2	3	13	4	1	3	0	0	29
Science and Mathematics: A formula for 21st Century Success	19	9	13	18	0	0	0	0	0	59
STEM Education: A Primer	2	0	4	0	0	0	0	0	0	6
Supporting STEM	21	3	4	5	1	9	3	0	0	46
The Federal STEM Education Portfolio	6	1	7	3	1	0	0	0	0	18
The Final Report National Advisory Report	12	0	4	24	0	0	10	0	0	50
The U.S. Science and Technology Workforce	10	0	2	0	0	0	0	0	0	12
Tapping America's Potential	12	1	2	7	1	0	0	0	0	23
Uteach Brochure	3	0	2	2	3	0	0	0	2	12
Totals	**240**	**136**	**209**	**256**	**116**	**12**	**87**	**57**	**7**	**1,120**

The first thing I notice from this table is that very few of the documents had the fallibilistic ontological claim or the transformative epistemological assertion. On the contrary, most documents had the three axiological claims together and many had both traditional and constructivist epistemologies present. To offer a concise picture of the policy documents, the analysis shows fairly equally democratic and utilitarian axiological claims and traditional and constructivist epistemological assertions. In addition, both the absolutist and aesthetic ontological assumptions were evident and seemed to be dispersed equally among the axiological assertions.

How does this analysis answer my second research question about coherency of policy documents? Perhaps it is a matter of interpretation. On one hand, a researcher could look at the wide arrangement of claims in axiology and how most if not all of them relate to epistemological claims and conclude that there is a lack of coherence. On the other hand, a researcher can observe that although the codes are widespread, they are consistently widespread through all the policy documents such that the different sub-codes are present consistently in each document. After I carefully studied this table, I have realized that coherency is simply not constant in the policy documents that I coded, but rather a variable. This is particularly interesting when considering Badiou's understanding of the state of the situation and the truth of the multiplicity of reality. For Badiou, coherence would not be a truth, but rather a second count that only acts as representative of the situation after it has undergone an operation by the state, or in my case, the writers of policy documents. However, the implicit claims and inherent assumptions opaque in policy documents are not meant to be coherent, but rather infinitely multiple. Hence, the coding scheme utilized in this study allowed for this truth to be revealed. However, to be more accurate, a different methodology, as shown in the next section, provides a more detailed analysis. This is where Badiou's philosophical methodology of set theory contributes an important component to the analysis of the data.

6.4. A Badiouian Analysis using Set Theory

In this section of the findings, I attempted a new methodology not used in policy analysis thus far: set theory. Set theory is a modern branch of mathematics and therefore it is a method by which to study sets. In mathematics, sets typically consist of numbers; however, for my purposes here, sets consist of policy documents and the codes that I have found in them. Badiou's use of set theory can be classified as a philosophical method. Since a philosophical lens for studying mathematics education policy grounds this dissertation study, it is appropriate to use a philosophical method.

While content analysis done in the previous chapter yielded a wealth of important information, it could not fully answer my research questions as they are framed by both my conceptual framework and philosophical lens. While it did answer what ontological assumptions were in policy documents and how they are correlated to epistemological claims and axiological objectives, it did answer the third of my research questions, which asks what potential implications for mathematics education does understanding these relationships provide to the teacher and to the students in the classroom. This question was anchored in my philosophical understanding of Badiou and what his theoretical lens could offer to mathematics education. Therefore, my objective in doing this work is to find where what Badiou terms the void may be located in mathematics education policy. In practical terms, my aim is to find where the coherence loses its structure in such a way that the discourse shows an anomaly that cannot be placed neatly within the overall discourse of mathematics education policy. It is this void, or glitch if you will, that may be the deciding place for change for the researchers who critique mathematics education policies, as well as a place of rich learning for educators to utilize in their everyday pedagogical and curricula decisions.

In what follows I attempt using the functions of set theory to see what coding categories become explicit in the documents and how such categories are related to one another. Badiou's definition of the "state of the situation" has been contextualized here to be U.S. mathematics education policy. What I am trying to understanding is within this situation, what kinds of discourses are left presented but not represented, since this is precisely where Badiou believes has the potential for the void to emerge and new revolutionary truths to become known to a subject or subjects that witness and remain faithful to it.

In this methodology every element is also a set itself and each set can be an element of another set. For instance the set known as a particular policy document has the subcategories from my coding as elements, but these elements are also sets since they contain all particular instances (quotes) found in the policy documents. My domain here is the set of policy documents that I have included in my analysis, which I explained in the methods chapter, were gathered by finding all the current nationally recognized U.S. public educational policy documents that had a clear interest in mathematics education. While this may be interpreted as a closed set mathematically, I am well aware that new policy documents can be decided upon and then disseminated at any point during my dissertation process. However, this limitation does not hinder my analysis since the robust domain I have collected and am analyzing here contains a wide array of policy documents that I feel best exemplifies the "state of the situation." Another important note to take into account when performing mathematical set theory is that the amount of times an element exists in any given set is of no consequence and is only shown once in the written set. Thus, in this method I am not interested in frequency of how many times a particular code appeared in a document, but only that it appeared once. Below I list all the policy documents and show what elements they contain.

21st Century Community Learning Centers: {AC, AD}
Blueprint for Reform: {AU, AC, AD, ET, EF}
Achieving the Common Core: {AC, AD, ET, OA, OE}
Adding it Up: {AU, AC, AD, ET, EC, OA, OF, OE}
America Competes Reauthorization Act: {AU, AC, AD, ET}
American Competitiveness Initiative: {AU, AC, AD, ET, EF}
A Parent Guide: {AU, AC, ET, OE}
Before It's Too Late: {AU, AC, AD, ET, EC, OA}
Coordinating Federal STEM Policy: {AU, AC, AD, ET}
Counting on Excellence: {AU, AC, AD, ET, OA}
CRS Report STEM 2006: {AU, AD, ET, EC}
CRS Report for Congress (2008):{AU}
Common Core Standards:{AC, ET, EC, OA, OE}
Curriculum and Evaluation Standards: {AU, AC, AD, ET, EC, EF, OE}
Defining a 21st Century Education: {AU, AC, ET, OA, OE}
Education and the American Jobs Act: {AU, AC, AD}
Everybody Counts:{AU, AC, AD, ET, EC, EF, OA, OF, OE}
Executive Summary NCTM: {AU, AC, EC, OE}
Gender Differences: {AD}
Highlights from PISA: {AU, AC, EF}
An International Perspective: {AU, AC, AD, ET, EC, EF, OA, OF, OE}
National Mathematics Advisory Panel: {AU, AD, ET, OA}
Math Teachers: {AU, AC, AD, ET, OA}
Mathematics and Science Partnerships: {AU, AC, AD, ET, EC, OA, OF, OE}
NCLB: A Desktop Reference:{AC, AD, ET}
NCLB Mathematics and Science Partnership: {AC, ET}
NMSI 2011 Annual Report: {AU, AC, AD, ET, EF}
Race to the Top Program: {AU, AC, AD, ET}
Report to the President Prepare and Inspire: {AU, AC, AD, ET, EC, OE}
Rising Above the Gathering Storm: {AU}
Science and Mathematics:{AU, AC, AD, ET}
Science and Mathematics Education Policy: {AU, AC, AD, ET, EC, EF, OA}
STEM Education: {AU, AD}
Supporting STEM: {AU, AC, AD, ET, EC, EF, OA}

The Federal STEM Education Portfolio: {AU, AC, AD, ET, EC}
The U.S. Science and Technology Workforce:{AU, AD}
Tapping America's Potential: {AU, AC, AD, ET, EC}
UTeach Brochure: {AU, AD, ET, EC, OE}

The code that appears in practically every policy document is AU, minus 6 documents, which means that AU was in 84% of the total policy documents. AC is missing in 8 documents, which means AC was in 80% of the total policy documents. AD is missing in 8 documents, the same as AC. ET is not in 10 articles a 26% discrepancy. This is an important finding since even though epistemology scored the highest overall coding frequency it was missing in more articles than the other popular codes. This means that although epistemology traditional was given discussed frequent in the policy documents, it was not discussed as much as other categories in all the policy documents combined. This makes sense given that some policy documents, like the Common Core or NCTM probably referenced epistemological claims often and many, but in other documents, ET was not mentioned at all. EC is missing in 18 articles, which means it did appear in 53% of the total policy documents.

The findings that are most interesting for this dissertation are in the ontological category, since I contend that our ontological assumptions we hold about what types of numbers/processes in mathematics are essential to epistemological claims about how best to teach mathematics and axiological objectives that specify the overall purposes mathematics education ought to serve. Overall, the ontological category (all three subcategories of OA, OF, OE) was missing in 20 out of the 38 documents, which means that was in 58% of the total documents. The code for ontology aesthetic played a more prominent role than I had anticipated in policy documents. My assumption that it would not be very common in the policy documents stemmed originally from my review of policy discourse and the overwhelming support of utilitarian objectives and social constructivist epistemologies, neither of which did I originally believe correlated with an mathematical aesthetic ontological stance based on philosophy of mathematics literature. The code of OA was not present in 26 of the documents and was present in 12. However, when accounted for only the documents that discussed ontology, which was 18 in total, OA occurred 67% of the time. OF occurred in four documents only, OE occurred in 12 documents and was not present in 26, the same as OA. This is an interesting finding to consider. I did not anticipate OE being as present in the policy documents as OA since my assumption was that traditional epistemologies would associate with an absolutist conception of mathematics and utilitarian objectives would also not be interesting in an aesthetic way of viewing mathematics. These incorrect assumptions I had about the way in which policy documents would correlate my three philosophical categories will be discussed in the next chapter. For now, I will say that this finding begs for a reexamination of my definition of coherency in policy documents, as well as a reevaluation of my philosophical categories as they relate to the practical nature of teaching and learning mathematics in the U.S.

I would like to come back to my original interest in this section, which was with my third research question and the Badiouian void. I believe the findings thus far give reason to explore the ontological category of aesthetics further, since my own assumptions as a professional educator and researcher caused me to be surprised about this finding. I believe many others in my position would also be surprised by this finding and therefore, I investigate, using set theory, more closely the policy documents that have the category OE within them. Below is the list of such policy documents:

Achieving the Common Core:{AC, AD, ET, OA, OE}
Adding it Up: {AU, AC, AD, ET, EC, OA, OF, OE}
A Parent Guide: {AU, AC, ET, OE}
Common Core Standards:{AC, ET, EC, OA, OE}
Curriculum and Evaluation Standards: {AU, AC, AD, ET, EC, EF, OE}
Defining a 21st Century Education: {AU, AC, ET, OA, OE}
Everybody Counts: {AU, AC, AD, ET, EC, EF, OA, OF, OE}
Executive Summary NCTM: {AU, AC, EC, OE}
An International Perspective: {AU, AC, AD, ET, EC, EF, OA, OF, OE}
Mathematics and Science Partnerships: {AU, AC, AD, ET, EC, OA, OF, OE}
Report to the President Prepare and Inspire: {AU, AC, AD, ET, EC, OE}
UTeach Brochure:{AU, AD, ET, EC, OE}

The reason for investigating these documents as sets is to find what they have in common as well as what elements relate to one another in particular sets. Above the documents that have at least one code for ontology aesthetics are listed separately now from the entire group of policy documents I have collected. The code for axiology utilitarian is found in all but two. And axiology cognitive is found in all but one. We have a combination of epistemology traditional and constructivist codes and a few fallibilistic ontology codes mixed in. Most predominant, though, are the links between ontology aesthetic and axiology cognitive and axiology utilitarian. Also quite important to note is the lack of axiology-democracy. Seven of them have the code ontology absolutism included. There are twelve total documents with OE, and seven have OA as well, that is about half or to be more exact 58%. Given how pervasive the absolutist claim seems to be, this might be an important finding. Since many documents could not even be coded with an ontological category, understanding the frequency of this code is difficult to discern. Out of the thirty-eight data points (policy documents), eighteen had any code for ontology. Out of those eighteen, only six had codes for only absolutism and not aesthetic. This leaves twelve of the documents that had any code for ontology to have also aesthetics represented. I believe this is an important finding since aesthetic category is well presented in the policy discourse, although its representation (how many times it explicitly gets referenced) is relatively small. Relative to the all the ontological codes, aesthetics had a stronger than expected showing, especially given the policy documents pertaining to utilitarian discourse.

With regard to the epistemology ontology relationship, out of the twelve articles that had OE code present; eleven had ET as well. This means that one did not have ET, but EC instead. I would imagine the EC code to appear more often with OE then ET since constructivist learning pedagogy often stress the importance of eliciting wonder and excitement for the learner. However, sometimes child-centered approaches fail to do so, especially when they do not take into account the aesthetic component of mathematics. This is a critique of constructivism that was discussed on length in Chapter 3.

The above list can only help us so far, which is again why I believe set theory can be a powerful methodology for my purposes here. Below, I conduct more set theoretical analysis using only the documents that have at least one code of ontology aesthetic. I begin by naming each document, alphabetically in bold, to better facilitate the set theory method. In this manner, a particular document is now defined as a set and the codes found within that document are elements in that set. They can also be “subsets” of a set if and only if all the elements included in one set are part of the larger set. For example, A is the set of codes found in a achieving the common core. For example, the set of AC is the set of coding expressions found in policy documents about mathematics education in the U.S. insofar as I have defined them in terms of a closed system of documents (the 38 I have collected as well as the coding scheme I developed utilizing the codebook and philosophical analytic constructs). Below, the first set is written in English as the set **A**, named Achieving the Common Core, and it has the elements AC, AD, ET, OA, and OE included with it. From now on when I use the bold capital "**A**" it stands for a particular policy document I have defined below.

A: Achieving the Common Core = {AC, AD, ET, OA, OE}
B: Adding it Up ={AU, AC, AD, ET, EC, OA, OF, OE}
C: A Parent Guide ={AU, AC, ET, OE}
D: Common Core Standards ={AC, ET, EC, OA, OE}
E: Curriculum and Evaluation Standards ={AU, AC, AD, ET, EC, EF, OE}
F: Defining a 21st Century Education ={AU, AC, ET, OA, OE}
G: Everybody Counts = {AU, AC, AD, ET, EC, EF, OA, OF, OE}
H: Executive Summary NCTM = {AU, AC, EC, OE}
I: An International Perspective ={AU, AC, AD, ET, EC, EF, OA, OF, OE}
J: Mathematics and Science Partnerships ={AU, AC, AD, ET, EC, OA, OF, OE}
K: Report to the President Prepare and Inspire ={AU, AC, AD, ET, EC, OE}
L: UTeach Brochure ={AU, AD, ET, EC, OE}

A technical note: The universal set always includes the null set and every set above includes the null set as well. For Badiou, this is crucial since the null set is potentially where the void is located and thus all possibilities of events to materialize. However, in set theory as used in mathematics, the null set is trivial, since it is by definition included in every set. I have not visually represented it in my analysis here because although I am searching for the void, I take Badiou's assertion that the event occurs during a singularity. This singularity is when there is an element in the situation, which is represented but not presented. I interpreted this theoretically assertion in my empirical analysis as finding a code that which stands out in some way beyond the representation of the codes in policy documents. Although I did not know what knowledge I would gain from doing set theoretical analysis on policy documents, I did so as a methodology and theoretical experiment. Regardless of this method's newness in analyzing policy documents, I utilized the formal conventions of set theory and as mathematicians often do, the work if done systematically and following the rules of agreed upon mathematical operations, the findings often are a surprise. Such as it was for me, as we shall see soon.

First let me say a bit more about the new sets I have defined above **A** thru **L** and the operations of set theory I use to study them. A union is an operation in set theory, which combines the elements in a group of sets. An intersection is an operation in set theory, which only includes the elements found in all the sets that are grouped. For example, the set whose members are X and Y is written: $\{X,Y\}$. The union of sets X and Y denotes the set of all elements in either X or Y (or both), written: $\{X \cup Y\}$. If set X has the elements 1,2,3 and set Y has the elements 3,4, then the union would be the elements 1,2,3,4. This is written as $\{X \cup Y\} = \{1,2,3,4\}$. The intersection of sets X and Y denotes the set of elements that are in both X and Y, written: $\{X \cap Y\}$. Again, taking the example just posed above, the intersection of sets X and Y would be 3. This is written as $\{X \cap Y\} = \{3\}$. Sets, X and Y are said to be identical when they have the same elements, written: $X=Y$. This would be the case if, for instance, set X had the elements 1,2,3 and set Y also contained the elements 1,2,3. Sets can also be subsets of one another, if all the elements found in one are found in another larger set. If set X has the elements 1,2,3,4 and set Y has the elements 3,4, then the set 3 and 4 is a subsets of the sets X and Y. This is written as $\{3, 4\} \subseteq \{X, Y\}$. Here, it is said that elements 3 and 4 is a subsets of the set X and the set Y or that set X and set Y both contain elements 3 and 4. The use of the subset symbol is useful as I compile the sets that contain the specified coding categories I am interesting in.

For our defined sets **A** thru **L** above, the following can be said:

- The Union of sets **A** through **L** is:
  A ∪ **L** = {AU, AC, AD, ET, EC, EF, OA, OF, OE}
- The Intersection of sets A through L is:
  A ∩ **L** = {OE}

In what follows, I investigate the sets, which include at least one code of ontology aesthetics and another code. I say "at least" one since there may be more then one code per document for ontology aesthetics, however as I explained in the previous paragraph, the frequency of the codes is not important here only that the code is contained in the document (which are now referred to as individual sets). I use the union and intersection functions of set theory to analyze the coding categories that are included in sets that also include the code ontology aesthetic. Since I have just separated the sets that include the code ontology aesthetics, I can further analyze them. I systematically connect each different coding category with the code ontology aesthetics by first finding the proper subsets of the sets of policy documents. Then I perform the union and intersection functions to this group of sets.

- Sets that include elements OE & OA are {**A**, **B, D**, **F**, **G**, **I**, **J**}, that is
  {OE, OA} ⊆ {**A**, **B**, **D**, **F**, **G**, **I**, **J**}
  Translated as the set OE and OA is a subsets of the sets **A**, **B**, **D**, **F**, **G**, **I**, **J**
- The union of the sets {**A**, **B, D**, **F**, **G**, **I**, **J**} is:

{AU, AC, AD, ET, EC, EF, OA, OE} = {**A** ∪ **B** ∪ **D** ∪ **F** ∪ **G** ∪ **I** ∪ **J**}
Translation as the set AU, AD, AC, ET, EC, EF, OA, OE is the union of the sets **A**, **B**, **D**, **F**, **G**, **I**, **J**

- The intersection of the sets {**A**, **B, D**, **F**, **G**, **I**, **J**} is:

{AC, ET, OA, OE} = {**A** ∩ **B** ∩ **D** ∩ **F** ∩ **G** ∩ **I** ∩ **J**}
Translation as the set AC, ET, OA, OE is the intersection of the sets **A**, **B**, **D**, **F**, **G**, **I**, **J**

- Sets that include elements OE & OF are {**B**, **G**, **I**, **J**}, that is:

{OE, OF} ⊆ {**B**, **G**, **I**, **J**}

- The Union of the sets {**B**, **G**, **I**, **J**} is:

{AU, AC, AD, ET, EC, EF, OA, OE, OF} = {**B** ∪ **G** ∪ **I** ∪ **J**}

- The Intersection of the sets {**B**, **G**, **I**, **J**} is:

{AU, AC, AD, ET, EC, OA, OF, OE} = {**B** ∩ **G** ∩ I ∩ **J**}

- Sets that include elements OE & ET are {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **I**, **J**, **K**, **L**}, that is:

{OE, ET} ⊆ {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **I**, **J**, **K**, **L**}

- The Union of the sets {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **I**, **J**, **K**, **L**} is:

{AU, AC, AD, ET, EC, EF, OA, OF, OE} = {**A** ∪ **B** ∪ **C** ∪ **D** ∪ **E** ∪ **F** ∪ **G** ∪ **I** ∪ **J** ∪ **K** ∪ **L**}

- The Intersection of the sets {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **I**, **J**, **K**, **L**} is:

{ET, OE} = {**A** ∩ **B** ∩ **C** ∩ **D** ∩ **E** ∩ **F** ∩ **G** ∩ **I** ∩ **J** ∩ **K** ∩ **L**}

- Sets that include elements OE & EC are {**B**, **E**, **G**, **I**, **J**, **K**, **L**}, that is:

{OE, EC} ⊆ {**B**, **E**, **G**, **I**, **J**, **K**, **L**}

- The Union of the sets {**B**, **E**, **G**, **I**, **J**, **K**, **L**} is:

{AU, AC, AD, ET, EC, EF, OA, OF, OE} = {**B** ∪ **E** ∪ **G** ∪ **I** ∪ **J** ∪ **K** ∪ **L**}

- The Intersection of the sets {**B**, **E**, **G**, **I**, **J**, **K**, **L**} is:

{AU, AD, EC, OE} = {**B** ∩ **E** ∩ **G** ∩ **I** ∩ **J** ∩ **K** ∩ **L**}

- Sets that include elements OE & EF are {**E**, **G**, **I**}, that is:

{OE, EF} ⊆ {**E**, **G**, **I**},

- The Union of the sets {**E**, **G**, **I**} is:

{AU, AC, AD, ET, EC, EF, OA, OF, OE} = {**E** ∪ **G** ∪ **I**}

- The Intersection of the sets {**E**, **G**, **I**} is:

{AU, AC, AD, ET, EC, EF, OE} = {**E** ∩ **G** ∩ **I**}

- Sets that include elements OE & AD are {**A**, **B**, **E**, **G**, **I**, **J**, **K**, **L**}, that is:

{OE, AD} $\subseteq$ {**A**, **B**, **E**, **G**, **I**, **J**, **K**, **L**},

- The Union of the sets {**A**, **B**, **E**, **G**, **I**, **J**, **K**, **L**} is:

{AU, AC, AD, ET, EC, EF, OA, OF, OE} = {$\mathbf{A} \cup \mathbf{B} \cup \mathbf{E} \cup \mathbf{G} \cup \mathbf{I} \cup \mathbf{J} \cup \mathbf{K} \cup \mathbf{L}$}

- The Intersection of the sets {**A**, **B**, **E**, **G**, **I**, **J**, **K**, **L**} is:

{AD, ET, OE} = {$\mathbf{A} \cap \mathbf{B} \cap \mathbf{E} \cap \mathbf{G} \cap \mathbf{I} \cap \mathbf{J} \cap \mathbf{K} \cap \mathbf{L}$}

- Sets that include elements OE & AC are {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**}, that is:

{OE, AC} $\subseteq$ {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**}

- The Union of the sets {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**} is:

{AU, AC, AD, ET, EC, EF, OA, OF, OE} = {$\mathbf{A} \cup \mathbf{B} \cup \mathbf{C} \cup \mathbf{D} \cup \mathbf{E} \cup \mathbf{F} \cup \mathbf{G} \cup \mathbf{H} \cup \mathbf{I} \cup \mathbf{J} \cup \mathbf{K}$}

- The Intersection of the sets {**A**, **B**, **C**, **D**, **E**, **F**, **G**, **H**, **I**, **J**, **K**} is:

{AC, OE} = {$\mathbf{A} \cap \mathbf{B} \cap \mathbf{C} \cap \mathbf{D} \cap \mathbf{E} \cap \mathbf{F} \cap \mathbf{G} \cap \mathbf{H} \cap \mathbf{I} \cap \mathbf{J} \cap \mathbf{K}$}

- Sets that include elements OE & AU are {**B**, **C**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**}, that is:

{OE, AU} $\subseteq$ {**B**, **C**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**}

- The Union of the sets {**B**, **C**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**} is:

AU, AC, AD, ET, EC, EF, OA, OF, OE} = {$\mathbf{B} \cup \mathbf{C} \cup \mathbf{E} \cup \mathbf{F} \cup \mathbf{G} \cup \mathbf{H} \cup \mathbf{I} \cup \mathbf{J} \cup \mathbf{K} \cup \mathbf{L}$}

- The Intersection of the sets {**B**, **C**, **E**, **F**, **G**, **H**, **I**, **J**, **K**, **L**} is:

{AU, OE} = {$\mathbf{B} \cap \mathbf{C} \cap \mathbf{E} \cap \mathbf{F} \cap \mathbf{G} \cap \mathbf{H} \cap \mathbf{I} \cap \mathbf{J} \cap \mathbf{K} \cap \mathbf{L}$}

While all the above work has provided a rich description of how the coding elements have been structured with the documents, has it illuminated where the Badiouian void is? The key to investigating policy documents through a Badiouian lens is to understand what Badiou means by void, which for me is intrinsically tied with the event insofar as it is a necessary condition for the event to occur or be recognized by a subject. I understand Badiou's void as a place within a given situation in which something that is presented is not represented, or when an element of a set in any given situation belongs but is not included. For my analysis here, the void could be the place in the policy discourses that I have collected and coded that depicts something that seems not to be intertwined with the main focus of the policy discussion. Since, I have pinpointed the category of ontology and the subcategory of aesthetics as the anomaly in the discourse, since its code came up much more often than I had anticipated, it makes sense for me to investigate it further. Although the policy documents I have collected are a closed domain of policies in the U.S. that discuss mathematics education, there is nevertheless more in them together then in any one document. This idea of the whole is greater than its parts is key to understanding the power of set theory to analyze policy. This is because set theory methodology allows for each document to remain faithful to its elements, while contributing to a larger discourse that is the domain or state of the situation of policies in the U.S. about mathematics, therefore creating a broader and more intricate body of analysis that can tell researchers more than studying each policy document alone or in tandem. The analysis I have undertaken above reveals the underlying reality of STEM policies in the U.S. from the perspective of a researcher than has believed and shown proof that ontological assumptions play a significant role in mathematics education. Now, for the interpretation of the set theoretical operations I performed.

First, when observing the union created by the above combination of sets, only one element does not occur in every set – that is the OF and it was missing in only one set when I grouped the elements OA and OE together. Next, I noticed that in most of the intersections of sets very few elements were included other than the ones I had controlled for. For example in the sets that had OE and AU, the only intersecting elements were OE and AU. This was not the case for a few intersecting sets however: OE and EF, which had these elements in its intersection {AU, AC, AD, ET, EC, EF, OE} and OE and OF, which had {AU, AC, AD, ET, EC, OA, OF, OE}. Although the set that includes OF does not include EF and vice versus, the set that includes EF does not include OF. But it also doesn't include OA, but only OE. Yet, the set that includes OF does include OA, giving it one more element than its comparable here. Interestingly, when controlling for the sets with ontology of aesthetics and an epistemology of transformation or an ontology of fallibilistic, there were many more elements that belonged. This may be a key finding since it seems it is within these two sets (OF and EF) that more elements belong, but those same elements are rarely represented in other more prominent sets. Perhaps even more fascinating is the fact that these same subcategories received the least amount of codes overall as indicated by the content analysis done in the preceding section of the chapter. Back to the union operation again, OF was found in all but one, which means that EF was in all of them. This means that EF was represented in all the policy documents that contained the element OE. EF was not present in any of the intersections sets, other then when it was controlled, yet when this was the case, the set that emerged from the intersection of this control contained almost all the elements, minus OF and OA, found in the entirety of the policy documents.

Thus, being the subject of this analysis of policy documents on mathematics education, I claim that the void, at least for me, occurs within the discourse of a transformative epistemology. It is here that most of the other elements are included, yet the set itself (EF) is not included in the sets of its elements. Therefore, a fascinating turn in the Badiouian logic has occurred here. Rather than experiencing the event as the place where one element emerges from the void that either belongs but is not included or is presented but not represented, I have found instead a place where the very concept, which is not represented anywhere, included all the other concepts that are presented everywhere. The void occurs within the discourse of epistemology transformative since this is the element least represented in the policy documents, yet on the rare occasions that it is, all other elements in all the policy documents are also represented. I may argue that epistemology is present inherently in policies about mathematics education but not represented as Badiou would prefer, but I am unsure if this terminology now works for this particular state of the situation.

My findings here are perhaps different in degree but not in kind from Badiou's definition of the void. Badiou sees the void as occurring when some element in a set is presented but not represented; in other words, when something in a state of the situation belongs to it, but is not counted again or not allowed to be recognized for its belonging. In the policy set theoretical analysis that was done in this dissertation, I found the void to occur in a different way. The element that was not represented in any of the sets is itself included all the other sets. This translates for educational theoretic terms in interesting ways. How can the discourse that is not valued, which in this case is transformative pedagogy, contain the other more valued and normative discourses of the other categories, such as cognitive axiological objectives and absolutist ontological assumptions? These sets occurred in the policy documents that I coded and were not manipulated in any way. Thus, it seems that when policymakers do include the transformative epistemological stance, they also believe all other of the multiple axiological objectives, epistemological stances, and ontological assumptions are latent in it. These findings seem to contradict some of Badiou's assentation of revolutionary events and emerging truths, but I believe given the context of my analysis and theoretical frame, which is mathematics education in the current political situation of the U.S., such difference can be explained. I will do so in the last section of the proceeding chapter (7.4).

Chapter 7: Discussion

In this chapter, the findings from Chapter 6 are interpreted further in order to better understand what normative assumptions about mathematics are latent in U.S. society. This question was asked at the beginning of this dissertation and is an important inquiry to explore, since as I explained in the Chapter 1, mathematics and societal norms and values and intrinsically related. By applying the literature about mathematics education and philosophy of mathematics, in what follows, I explore the findings in this dissertation within the larger education discourse in order to better articulate the policy discourse, and what it means for our society and educational system at large. I have broken up this chapter into three sections, based on the analytic constructs that I used for the coding categories. I have also included a fourth section, to explicitly discuss how my findings explicitly answer my research questions, specifically utilizing the Badiouian set theory analysis done in the previous chapter.

7.1. Axiology: The different meanings of democratic education

As depicted in the above findings chapter, the axiological category was the most prominent code category in policy documents. Even though the traditional epistemology code was the highest in frequency, when combined with the other epistemological codes, the totality of the axiological codes was quantifiably larger in frequency in the data. This is an obvious finding since policy documents are inherently about objectives in mathematics education or the end result a given reform package ought to strive for. What are fascinating in this study are the relationships between the axiological codes within themselves, as well as their relationship with epistemological and ontological codes occurring in the same documents. My premise before conducting the empirical work of this dissertation was that the utilitarian code would occur the most. I was surprised to learn that democracy was very much part of the discourse in policy. Further, I was intrigued to notice how the discourse on democracy was intertwined with ontological and epistemological assumptions.

The discourse on democracy was widespread indeed, but appeared fragmented once analyzed in greater detail. Especially when taken in light of the ontological and epistemology context of the policy document itself, democratic axiological claims seemed to explicitly say one thing yet implicitly say something else. The notion of citizenship was especially interesting since it correlated with utilitarian objectives so strongly; even more fascinating was that the typical utilitarian education objective of finding a job seemed subsumed with a larger societal utilitarian aim of creating a competitive national workforce. Let me offer some examples of these incoherencies in my data set (citizen in bold not in original text):

- "For people to participate fully in society, they must know basic mathematics. **Citizens** who cannot reason mathematically are cut off from whole realms of human endeavor. Innumeracy deprives them not only of opportunity but also of competence in everyday tasks" (*Adding It Up*).
- "By giving **citizens** the tools necessary to realize their greatest potential, the American Competitiveness Initiative (ACI) will help ensure future generations have an even brighter future" (*American Competitiveness Initiative*).
- Our democracy's need for an educated **citizenry.** It is not just the role that mathematics, science, and technology play in the changing economy and workplace that matters. Mathematics and science have become so pervasive in daily life that we tend to overlook them. Literacy in these areas affects the ability to understand weather and stock reports, develop a personal financial plan, or understand a doctor's advice. (*Before It's Too Late*)
- Quality STEM education is important for the nation as a whole and for individual **citizens**. A robust and capable STEM workforce is crucial to United States competiveness. (*Tapping America's Potential*)

From the above examples, notice how the notion of citizen is equated with both utilitarian aims of a person's ability to handle daily life with democracy's need for "an educated citizenry." The claim is that a person cannot function adequately in today's society without a high level of mathematical knowledge and this inadequacy hampers democratic participation. In the last quote, notice how the nation's competitiveness and workforce is related to democracy as well. I wondered here how democracy and citizenship on one hand are related to economic competitiveness for the nation as well as workforce readiness for the individual on the other. I would like to take a closer look at this connection. Here are some quotes that directly discuss competition and workforce:

- "Highly skilled workers, trained in science, technology, engineering and mathematics, are the ones who generate breakthrough innovations that lead to productivity gains, economic growth and higher standards of living. America enjoys a high standard of living, but we are falling behind in producing the technical talent we will need to sustain our economic leadership in the world." Joseph M. Tucci Chairman, President and CEO EMC Corporation (*Tapping America' Potential*).
- "Education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy. For the U.S. to maintain its global economic leadership, we must ensure a continuous supply of highly trained mathematicians, scientists, engineers, technicians, and scientific support staff as well as a scientifically, technically, and numerically literate population" (*America Competes Act*).
- "For the United States to continue its technological leadership, as a nation requires that more students pursue educational paths that enable them to become scientists, mathematicians, and engineers" (*Adding It Up*).
- "We know that the progress and prosperity of future generations will depend on what we do now to educate the next generation. Today I'm announcing a renewed commitment to education in mathematics and science...Through this commitment, American students will move – from the middle to the top of the pack in science and math over the next decade – for we know that the nation that out-educates us today will out-compete us tomorrow" (*Tapping America's Potential*).

It is unclear how creating skilled workers for the U.S. to maintain its global economic status is comparable to ensuing all Americans find meaningful employment.

How exactly does a "literate population" contribute to economic wellbeing for both individuals and nation wide? Further, why do policymakers believe knowledge in STEM fields will be beneficial for the average U.S. citizen in obtaining a future job?

The connection between education and employment seems to be most easily made with mathematics. After all, mathematics education policy is typically depicted as politically neutral. As the great equalizer and the queen of abstraction, mathematics is seen as impenetrable to critique (Apple 1992; Martin, 2003). Therefore, when the government wants to improve mathematics, it is difficult to find a fault in such an altruistic tautology. Martin (2003) explains "what is good for the economy is obviously good for you…unequivocal advancement of workforce needs and national competition necessarily takes mathematics education out of the sheep's clothing of being politically neutral" (p. 363). This ideology is reflected in free market ideals. In mathematics education policy, this idea translates into businesses and corporations playing an increasingly important role in schools.

Gutstein (2008) asks provocative questions, such as how does the rhetoric of economic competitiveness translate to better individual lives for all citizens? His answer is that the "crisis" of economic competitiveness and its proposed solution only benefits a small section (approx. 1%) of the population. He raises a crucial point where he asks will America will actually have the jobs in the future for all its highly skilled workers? In fact, "the majority of US workers in 2016 will need at most short or moderate term on the job training (not college)…" (Gutstein, 2008, p. 419).

Policymakers believe that math is the great equalizer or the gatekeeper to high paying jobs and social mobility; in other words, it legitimates meritocracy in the neoliberal ideology of competitiveness. This view is too narrow and simplistic and has produced no empirical validity to back up its assertion. Woodrow (2003) showed how in Asian economics, math scores went up only *after* the country reached a certain economic level, not the other way around. Other studies have shown this disconnect as well. Ortiz-Franco & Flores (2001) researched that although Latino students' math scores have increased, their socioeconomic status has remained low (cited in Atweh, 2007). Lindsay (2007), director of policy studies at Georgetown University Institute for the Study of International Migration, argued that the educational pipeline in math and science "is not as dysfunctional as believed. Academic standards and test scores have improved and K-12 and college institutions are producing plenty of well qualified students" (cited in Steen, 1997, p. 26). The problem, as she sees it, is that the science and engineering firms are not attracting or retaining these graduates. This fact ought to cause us to wonder why policy discourse in mathematics education so fervently claims that we need more students with high-level mathematics background if there simply aren't enough jobs to utilize these graduates? If we only need a few people to drive our country into economic prosperity, why the rhetoric of mathematics reform to serve the needs of the general population?

Gutstein (2008) makes a convincing argument that NCTM and NMAP were primary for keeping America competitive and addresses the danger of the US economy losing its supreme status. He writes the stated goal of the NMAP was to foster a national conversation on mathematics education, which it did only by disregarding equity and class issues. Martin (2003) argues further that increased politicization of mathematics education for workforce objectives is highly influenced by ideological and societal structures. Arguing that in fact the NMAP is condoning a "white institutional space," Martin explains that recent policies and discourses in mathematics education are "specifically geared to serve the needs and privileges of white perspectives, white ideological frames, white power, and white dominance" (p. 389). Martin (2003) also offers this analysis:

> The fact that the nation does not have the capacity, or moral commitment, to absorb all of those who would be trained in mathematics and science. Simple supply and demand would dictate that the overproduction of engineers and scientists would lead to declining wages and standards of living and would put downwards pressure on those at the lower rungs of the labor market, creating an even wider gulf between high level of education and those without it (p. 394).

This work began with the strong assumption that in today's perceived climate of competitive global struggles over immaterial resources, no other domain has played a more foundational role than mathematics and its education. While this crucial line of inquiry cannot be addressed in this dissertation, it is important to call attention to the broader sociopolitical context in which policies on mathematics education are currently framed. Obama's *Educate to Innovate* (2010) campaign involves corporations and philanthropies and does so as if it is commonsensical to involve private corporations in public affairs. In this discourse, rarely is it asked what is the role of the government for its citizens? Our capitalistic economic system assumes that private individuals naturally compete against others with little intervention needed from national or social agencies. No more does the community or public have a corporative role, nor even the nation-state a responsibility to its citizens. The theme of competition permeates down to the microorganism, such that each cell in a body is viewed as fighting for scarce resources; this translates to students, workers, and finally nations who compete against each other. There are two assumptions here: one that competition is an innate part of life in this world and two that there are actually scarce resources on this planet that ought to be fought over.

I believe the above societal norms and the policy discourses that compound them are groundless and have no empirical validation, but worse, these assumptions are harmful to human life, our continuing cry for peace and harmony on this planet. Moreover, I believe our tendency to conceptualize mathematics in absolutist category perpetuates these values insofar as numbers are seen as discrete static entities that depict the in objective terms the magnitude and worth of anything living or not. What if we transposed such ontological assumptions into a more aesthetic conception of mathematics? Perhaps if we realized the structure of numbers, and the processes that define them, cannot exist without forming a relationship, a patter if you will, with themselves. Numbers do not compete, since each shares elements with another and these in turn come together to create more complex sets. If we come to understand mathematics in this way, how might we metaphorically view ourselves as not just beings that can be measured quantifiably, but as people who cannot exist without one another. This idea might mean a new way of imagining democracy and citizenship within such framework. I wonder if an education system that teaches or allows the possibility for mathematics to be understood in aesthetic terms might foster such a new democratic future?

Another important theme in the codes about democracy was the inclusion of minorities and other underrepresented groups. This discourse often used the words "every" and "all" and also played a prominent role in the utilitarian codes about mathematical literacy as well as economic competitiveness. Here are several examples that use this discourse and therefore have been coded as axiological democracy:

- "In this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed. The National Council of Teachers of Mathematics (NCTM) challenges the notion that mathematics is for only the select few. On the contrary, everyone needs to understand mathematics. All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding. There is no conflict between equity and excellence" (*Executive Summary NCTM*).
- "Providing a high-quality education for all children is critical to America's economic future. Our nation's economic competitiveness and the path to the American Dream depend on providing every child with an education that will enable them to succeed in a global economy that is predicated on knowledge and innovation. President Obama is committed to providing every child access to a complete and competitive education, from cradle through career" (*America Recovery Act*).
- Agency Mission Workforce Objective 1: Ensure that a well-qualified pool of candidates is prepared to meet the current and future STEM workforce needs of Federal agencies and related industries. Agency Mission Workforce Objective 2: Ensure that a well-qualified pool of candidates for Federal agencies and related industries reflects the diversity of the Nation" (*Tapping America's Potential*).

Stanic (1989) contends that equity has never been the real aim of reform movements in mathematics education. "Most present day arguments for reform in mathematics education advocate more math for more people and are based on the belief that there is an inevitable flow of society towards greater reliance on mathematics, science, and technology and towards international competition for resources. There is no reason to believe that such a society would be more just or that such a society would encourage greater equity in school mathematics" (p. 61). A wide array of scholars have recently critiqued, in the Educational Researcher (2008) journal devoted to the theme, the reforms advocated by the National Mathematics Panel (Cobb & Jackson, 2008; Kelly, 2008; Spillane, 2008).

7.2. Epistemology: The emphasis on teachers and teacher education

A large concern in mathematics education policy reforms is the quality, expertise, and retention of teachers. While much of the STEM policy discourse centers on increasing the funding for technology and quality materials in schools, the overall rationale is that these resources are not going to fix the problem of low mathematics scores on standards tests as much as the impact teachers can have in the classroom. Unfortunately, very little discussion pays attention to the larger socioeconomic spheres that have been shown to directly relate to how well students learn (e.g. Apple, 2004; Gabbard, 2000; Giroux, 2005). Regardless of this blatant disregard of socioeconomic conditions, I concentrate my discussion here on the emphasis on teachers and teacher education in policy documents about mathematics education. Since teachers are framed as being the sole source of increasing children's understanding of mathematics, their knowledge of the discipline is often questioned. This leads to policies advocating for more teacher education, more assessment on their performance, and more accountability to ensure that the correct person is deemed responsible for U.S. children's standardized test results. Key words within this discourse are accountability, assessment, knowledge, and qualified. Here are some examples from the policy documents in the data set.

- “Fundamental to improving student learning and achievement is the presence of highly qualified teachers in every classroom.” And “Research confirms that teachers are the single most important factor in raising student achievement” (*American Competitiveness Initiative*).
- “The most consistent and most powerful predictors of higher student achievement in mathematics and science are: (a) full certification of the teacher and (b) a college major in the field being taught” (*Before It’s Too Late*).
- “’To me, the lesson is that while there are no silver bullets to chip away at poverty or improve national competitiveness, improving the ranks of teachers is part of the answer. That’s especially true for needy kids, who often get the weakest teachers. That should be the civil rights scandal of our time’ by Nicholas D. Kristof, The New York Times, Jan 21, 2012” (*UTeach Brochure* p. 5).

Several key points to take away from these examples are that “research” is used to justify the claim that teachers ought to be held responsible for their students success, above and beyond other factors such as S.E.S. (social, economic status) and that teachers ought to have more content knowledge about mathematics. In the past, secondary teachers were required to have a certain number of college hours devoted to mathematics (if this was what they were teaching); however, currently elementary teachers whose job is interdisciplinary by design are asked to have more focused instruction in mathematics. This shift in prerequisites of content knowledge coupled with the reduction of pedagogical expertise may extend to all subject areas; however, in mathematics it seems even more stressed since relatively few adults enjoy and feel they are good at the subject. Certainly, the debate over content verses pedagogy has been going on for some time, but it seems obvious at this point at least which side is winning. Nevertheless, policymakers and teacher educators ought to ask what are we losing by disregarding pedagogical skills over content knowledge? Further, what kinds of messages are being broadcast to children about what is valuable in society? These questions are compounded when children become aware that the very people, their teachers who are being held accountable for disseminating such valuable knowledge are themselves being critiqued and sometimes even shamed.

Rarely in the policy documents that I coded are teachers themselves personified or given a voice. Rather, they are depicted as a workforce that is needed for economic success. Fullan (1993) in his book, *Change Forces: Probing the Depths of Educational Reforms*, says that what should be a theme in educational reforms in the U.S is teachers as change agents. He sees the reform efforts as failing because they offer no relationship among teachers as social agencies. According to Fullan, to even begin to succeed, any policy must take into account the culture of schools and the complex relationship the workers and educators inside the buildings have amongst each other, the students, and the families they serve. Even more striking is Fullan's insistence on the process of policy reform rather than the outcomes, since change and unforeseen circumstances are guaranteed in the policy implementation process. The failure of the education policy, as Fullan contends, is its lack of giving full attention to teachers and teacher education. He writes "…[it's a] Catch 22 – society blames teachers when the reforms don't work, yet it does not give them ways to improve the conditions for success". Fullan continues by saying that "teachers have not helped themselves" and "systems don't change when people wait for someone else to correct the problem" (p 104). While the prior quote is a bit harsh, he goes on to say that, "teacher education still has the honor of being simultaneously the worst problem and the best solution in education" (p. 105). While, I agree with Fullan and believe some of the work in this dissertation can aid in empowering teachers to become agents of change rather than scapegoats for educational reforms gone bad, I also feel that teachers can only be part of the solution, since school reform is a complex issue that incorporates many influences that are outside the educational system's influence, such as poverty, racial, ethnic, and economic prejudices, and economic cultural forces that have caused millions to lose their jobs and their homes.

There is still optimism in education to help alleviate the disparities in social economic state. Fullan believes that a teacher must have the following three kinds of knowledge in order to serve as change agents in their classroom and school district:

1. Knowledge of professional community
2. Knowledge of education policy
3. Knowledge of subject area (p. 113).

The three categories of knowledge above differ from the way in which teacher's knowledge is typically prescribed. When I became a teacher, the debate centered around which type of knowledge a teacher ought to have more of: content or pedagogy. This debate still goes on today, but both sides agree that a teacher's knowledge belongs in the skills and disposition needed in the classroom. Fullan's model is different since he seems to disregard pedagogy as a separate category and inserts professional community and education policy. Subject area knowledge is traditionally the knowledge needed about the subject one is teacher and encompasses pedagogical knowledge since a teacher must also possess the necessary understanding for how best to teach the content. Knowledge of education policy, Fullan argues, is needed since it affords a teacher a broader view of education, which transmits to a greater understanding of how to teach, not only a particular subject area, but in a particular social-economic context in which the classroom is always a part of. Further, knowledge of policy enables a teacher see the complex discourse of educational reform efforts and therefore able to be more fully a part of the implementation process.

Knowledge of the professional community speaks to the effort of garnering in a teacher a disposition of collaborative, inter-disciplinary approaches, and professionalism. This last type of knowledge is especially advocated in other countries. Chinese teachers are viewed as producers of research, not just as consumers of research. They also have many outlets for publishing their classroom case studies, in contrast to the situation in the United States, resulting in more professional journals oriented to teachers than to researchers (Klein, 2003). Klein writes, “In comparing the teacher preparation of Taiwanese, Japanese, Korean, Finnish, and American teachers, four areas in which differences may occur are ongoing professional development, teacher background in educational research and pedagogical studies, teacher mathematical background, and the presence of a professional, collegial community for teachers” (p. 17).

Although content knowledge, according to Fullan, is a key knowledge category for teachers, it is not the only one. A professional community is surely an important ingredient to consider as policymakers and teacher educators think about ways to strengthen the teaching profession in the U.S. Teachers, viewing themselves as professionals could contribute greatly to their field and form collaborations that could generate important information for teaching and learning. However, these findings and the knowledge generated by teachers ought to influence educational policy. In order to feel that they have some agency, teachers must understand the reform discourses in their complexity (Ingersoll, & Smith, 2003, p 6). Before teachers can become the change agents policymakers ask them to be, they must be fully knowledgeable about the past and current policy literature. The first way this can be done is to not have the policy and research be *about* them, but *for* them. This is similar to the key distinction I made in Chapter 1 about policy research either *for* policy or *of* policy. This means teachers should not just be implicated in policies, but become key participants in creating, critiquing, and disseminating policy recommendations and implementations. The first step to accomplish this task is in teacher education. It is there that teachers should learn more about how policies are formed, and why, and what many facets they consist of. In this way, teachers become active participants in the policy reform efforts and this would only enhance the teaching and learning of mathematics for any objective.

7.3. Ontology: The surprising aesthetic component

I must admit that my assumption was that the ontological code of absolutism would be the most popular code for ontology. While this is true by quantity, the aesthetic code came up a lot more than expected. Moreover, the way in which it occurred in the data and the relationship with other codes is quite interesting. Here are some examples from the policy documents:

- "As discussed below, even students who graduate with strong math skills on paper often have trouble when it comes to put them to use in the real world. Finally, the team could not have tackled the challenge if its members were not able to work together collaboratively, communicate with each other effectively, and solve problems **creatively**. All of those competencies had to work together with practical mathematical literacy and discrete kinds of math skills in order for the team to be successful" (*21st Century Skills*).

- "School districts should also consider whether the learning environment in their schools encourages open ended curiosity, comfort with "no right answer," **creativity,** taking personal responsibility for identifying and solving problems—in other words, whether it reflects the evolving workplace environment" (*NCTM Executive Summary*).
- "Mathematics is not a collection of separate strands or standards, even though it is often partitioned and presented in this manner. Rather, mathematics is an integrated field of study. When students connect mathematical ideas, their understanding is deeper and more lasting, and they come to view mathematics as a **coherent whole**" (*Adding It Up*).
- "Third, as science and mathematics provide human beings with powerful tools for understanding and continually reshaping the physical world itself, they teach us again and again that Nature's secrets can be unlocked—in short, that the new is possible" (*Common Core Standards*).
- "Mathematics is a universal, utilitarian subject—so much a part of modern life that anyone who wishes to be a fully participating member of society must know basic mathematics. Mathematics also has a more specialized, esoteric, and esthetic side. It epitomizes the **beauty** and power of deductive reasoning" (Adding it up).
- "Virtually all young children like mathematics and learn mathematics through natural **curiosity**" (*Everybody Counts*).

The most surprising finding in the empirical work of this dissertation is the preponderance of the aesthetic ontological concept of mathematics inherent in education policy reform documents. Not only did this code show up in places more expected like the *NCTM Principles and Standards*, but it also appeared in aggressive national policies advocating for economic incentives such as *Adding it Up* and *Everybody Counts*. This finding has made me rethink my own bias about national policy reforms in mathematics education, which I used to believe more ill-conceived and lacked comprehension about the very field of mathematics. I must acquiesce and admit that my own subjective and prior limited understanding of policy discourses have been too simplistic. It now appears that policymakers, at least at the national level, do have a greater understanding of the mathematics and how it is learned then I had originally thought.

Based on the policy discourse uncovered in this dissertation, mathematics is ontological, conceived as a field drenched in beauty, imagination, and power. The policy recommendations call for more creativity and curiosity to be interwoven in the way teachers conceptualize the field of mathematics. Many cognitive scientists would strongly agree with these recommendations (e.g. Devlin, 2000; Dehaene, 1997, Damasio, 2005). The work of modern neuroscientists like Damasio (2005) illuminates how the human brain's structure has evolved to our present modern capacity for abstract and creative thinking. The new field of brain imaging technology, in which Damasio is a pioneer, gives evidence to support the idea that there are inherent evolutionary traits, which govern our ability to discern patterns and quantities in our externally constructed reality. For Damasio, these biological traits are not simply cognitively based, but emerged out of a complex interconnectivity between mind, body, emotion, reason, and ecological and social environment.[i] Another cognitive scientist, Devlin (2000) argues that the ability to think about thinking is the very mechanism that launched humanity into our distinctive evolutionary course.

Traditionally, teachers of mathematics believe that students can only grasp complex principles by first learning simpler ones. This linear spiral model has merit only in an outdated and empirically disproven Piagetian development theory. Educational theorists coming from Vyogskian scholarship, (Davydov, 1995; Schmittau, 2005), argue that cognitive development actually descends from abstract thinking to concrete. This theory drastically changes how we ought to think mathematics should be taught. Davydov explains that mathematics is a relational system that cannot be meaningfully understood through explicit concrete problem solving. Rather, children should be able to explore the theoretical and structural components latent in the mathematics they are studying, which according to Davydov would ground their concrete experience with mathematical problem solving. This way of teaching is implicitly recursive, since it follows from the larger concept to the smaller ones, each playing a role in the overall teaching and learning of mathematics.

Another way of thinking about recursion as a pedagogical technique is the concept of meta-thinking. Meta-thinking, or thinking about thinking, can help students assimilate their concrete understanding of mathematical processes with the abstract concepts. For example, fractions are typically seen as a roadblock for many and the current constructivist's techniques as advocated by the U.S. National Council for Teachers of Mathematics are not adequate for those that struggle with conceptualizing part/whole relationships. Recursive thinking can help these struggling mathematics learners. Students can be shown the fractional components visually and perform various experimental lessons to manipulate them. Further, meta-thinking would delve deeper into the structure and very meaning of fractions. Fractional concepts should be shown in their entirety and then deconstructed to gain a deeper understanding. This pedagogical pattern allows for students to ask more meaningful questions about the concepts they are struggling with since they have a larger set of knowledge in which to guide their own constructive learning process. The TIMSS and the PISA videos and subsequent research done on these international studies reveal that countries that score a high level of academic achievement in mathematics incorporate teaching techniques like the ones described above. The teacher in a Korean mathematics classroom begins the lesson with the larger, more holistic view of the concept being studied, and then proceeds with breaking the lesson down. If the United States could incorporate this type of approach, cognitive learning of mathematics would improve tremendously. Recursion is a model concept by which pedagogical techniques can be reconfigured and thus enable mathematics to be taught more effectively as well as enjoyably.

Imagination plays an integral role in mathematics exploration. Rarely do we think about mathematics as an artistic discipline, yet as the authors of *Imagination and Education* pontificate "…the rational world of mathematics and logic is also a human creation and a product of the imagination…" (Kobayashi in Blenkinsop, 2009, p. 50). Mathematics is a field par excellence of imaginative thinking, since its foundation is the realm of pure thought and reason. The ability to use one's imagination is perhaps the most important characteristic for gaining a strong, meaningful understanding of mathematics.

7.4. Discussing the Research Questions

1. What ontological conceptions of mathematics are embedded in U.S. educational policy reform initiatives?
2. To what extent are the ontological conceptions of mathematics coherent with pedagogical and educational objectives of the policies?

3. What potential implications for mathematics education does understanding these relationships provide to the teacher and to the students in the classroom?

In this section I would like to discuss the findings as they explicitly relate to my original research questions, which I provided above. The first research question is easy to answer since it is merely a description of the findings. The analysis shows that while all three ontological categories were in the policy documents, the categories of ontology absolutism and ontology aesthetic were the most prevalent. Further, these codes were in more documents than had been anticipated by this researcher. I believe this finding as well would surprise most teachers. Ontological conceptions, after all, are more of a philosophical way of thinking about mathematics than epistemology and axiology categories. Although teacher education courses discuss pedagogical theories and best practices for teaching mathematics (epistemology) and review the rationale for why mathematics education is so important (axiology), they rarely discuss what mathematical concepts/processes are and how to think about them in relate to the work of teaching mathematics. My conclusion is that ontological categories are present in the policy discourse and as such, they should also be more explicitly present in teacher education courses and in mathematics education classrooms.

The second research question became the most difficult one for me to answer as the findings materialized. I began this dissertation asking the question of coherency believing that it was important for policy documents to have this trait. As I conceptualized this concept, I believed that coherency in policy documents would be exemplified by a reoccurring pattern in the way my three philosophical categories (my later termed analytic constructs) would relate to one another in the policy documents. I imagined that when a particular axiological category was present in one document, a particular epistemological and ontological category would also be present. This idea became nonsensical during the process of writing this dissertation, both during the empirical process and after a careful juxtaposition within my theoretical lens. Empirically, no such coherence became apparent. Perhaps, I could make an argument that certain categories did indeed always appeared with others, but the broad array of codes with any given policy document, much less all of them, makes such a claim impossible to make. Revisiting Badiou's assertion that reality is multiplicity and any type of coherency one sees is merely an illusion either created by oneself or through an operation by the "state", which for Badiou is any governing body or group that holds influential power. Badiou would think it is absurd to assign a positive quality for policies that are in fact coherent, since for him only a "second count" can render a policy to seem coherent. This "second count" becomes what Badiou terms "the state of the situation." Prior to this count there is only inconsistent multiplies and the "state" and after this operation there is consistent multiplies that can now be counted (i.e. represented in policy documents are coherent). Thus, a policy can only appear coherent, but upon inspection or in the case of this dissertation study, upon analysis, that which s presented becomes apparent. It is here that the void can be witnessed and revolutionary change can occur once a subject arises that lays a wager on such an event.

The findings in this dissertation show that there is indeed incoherency in U.S. mathematics education policy documents. Such incoherence, I contend, is a wonderful sign that our educational leaders are on the right track when creating sound practices and not vice versus. Perhaps policymakers, with their need to include so much complexity in their initiatives, confound the void more than it typically appears in the “state of the situation.” The void in mathematics education policy is found where ever an epistemological theory that speculates on how mathematics is a powerful tool that governs our society (i.e. epistemological transformative category). This void also is anchored by an aesthetic ontological conception of mathematics. Therefore, when mathematical entities are understood as relations in a structure, the knowledge that can be produced has the potential for transformative change to occur in our society.

The findings of this dissertation, while not aligned exactly with Badiou or the current work utilizing his theories in education, nonetheless maintain the Badiouian lens, and I believe move the theory further into the educational realm where many scholars have asked that it transfer. Perhaps the reason for the differences in theory lie in the contextual reference points that grounded my work, which is policy documents. Policy documents, after all, are not real spaces, as they do not exist in an existing classroom or in a social or political gathering. Rather, policy documents are representative of the normative claims found in our society, even if such claims are made by a small group of elite powerful policymakers. Thus, Badiou’s revolutionary work has to be reinterpreted within each context it is being applied to. And this, I believe, is precisely what Alain Badiou would want. Therefore, much more work needs to be done to conceptualize how Badiou’s philosophy can be applied to mathematics education. I attempt to provide a preliminary sketch of this and answer that third research question regarding implications in the next chapter (section 8.2) titled "pedagogy of the event."

Chapter 8: Conclusions

Assuming the overriding intention of education policies is the betterment of teaching and learning of mathematics, researchers should envision how their work can contribute to this goal. Thus, an empirical study on policy ought to strive to generate useful information for teachers and theorists to help foster exemplary mathematics teaching and learning in the classroom. I believe this dissertation has fulfilled this requirement in two important ways. The analysis of the philosophical components of policy documents about mathematics education has illuminated the structure of the discourse in its complexity. Having a conceptual map of the policy discourse is useful for educators since it provides information they might otherwise not have, and this information is useful for them to navigate their professional lives, which are always influenced by policy decisions they have little control over. A teacher that understands the philosophical foundations behind pedagogical practices they are being asked to teach is that much more confident and prepared to teach. Moreover, a teacher who possesses the in-depth knowledge of the aims of policies they are required to implement in their classroom, is that much more aware of their own agencies in the implementation process and perhaps this awareness can also help make a space for praxis to occur within the classroom. This would be Badiou's hope and so it is mine as well. Thus, while I have asserted above that this dissertation fulfills the goals of an educational researcher, I contend that it has done more than that. The overarching objective of this work is to explore the complexity of mathematics education policy in the U.S. to envision how our society comes to value mathematics. Since my presupposition is that mathematics is central to our society and that our society has inherent flaws that breeds social injustices, then it seems apparent that to combat these a new conception of mathematics is necessary. For such a change to occur the teaching of mathematics must change, as well as the overall educational mission of what mathematical knowledge ought to be used for. Kuhn believed that change could occur through what each termed a "paradigm shift;" rather I believe such a shift is only possible through a shift of our ontological perspective of our world. A small revolution in the way in which mathematics is conceptualized in the classroom has the potential to change our ontological perspective and thus opens the pathway for a greater revolution to take place.

The other way this dissertation has fulfilled the requirement of providing useful information is that it has given researchers an alternative lens in which to analyze policy texts. In the quantitative/qualitative empirical divide researchers are often compelled to stay within one format. I believe this is unfortunate since new formats can illuminate information that might be left otherwise unexplored. While content analysis has been used as a methodology in educational research, it has had limited uses in policy analysis, and less so in mathematics education. The unique contribution I have made in this dissertation is incorporating an explicit philosophical framework both as a supplement to content analysis and as a foundation to it. The set theoretical analysis I supplemented as my last analytic tool moved the findings further than the content analysis was able to do. In addition, the analytic constructs, which were grounded in philosophy of mathematics literature, enabled categories to be well defined, which strengthened the content analysis methodology used in this study.

This final chapter of the dissertation first discusses the limitations of the study and the implications for the methodology the study utilized. The second part of this chapter looks forward to how this work can aid professional educators in their daily mission to provide exemplary mathematics instruction in their classrooms. Last, several remaining thoughts are given about the dissertation and future theoretical and empirical work that ought to follow this study.

8.1. Limitations & Implications

Limitations of the study include the fact that there was only one principal investigator for the entire data set, thereby hampering the internal reliability of the findings. I have tried to counter this limitation in several ways: first, I attempted to be as transparent about my coding strategy as possible by providing numerous coding examples and generating an abundance of descriptive charts and tables to show the findings in multiple ways. Second, I created a codebook at the beginning of my analysis and as it developed, and after I completed the coding of all the data, I revisited the codebook regularly to make sure that the codes were consistent throughout the coding of all the documents. In addition, I sought advice from several other researchers that have conducted their own studies using similar methodologies; these researchers' advice and critiques provided that critical lens by which I was able to maintain a level of reflexivity with my data and the results I was obtaining through the coding process. Last, my extensive literature review on mathematics education policy and policy research provided a foundation for the design of the study itself, which I believe anchored the whole project and gave it validity. Other limitations were the unsystematic data that was found. Since my data set was to include all policy documents that related to mathematics education and were made for public dissemination in the last decade, it was impossible to know before the study began exactly what my data set would consist of. This is because each data point had the potential for referencing another important document, which I then retrieved. I wanted to keep this process open so I could include policy documents that I may have otherwise left out. Hence, although this collection practice is not systematic, it was comprehensive. These limitations notwithstanding, I believe that the results revealed in this work, along with the methodology used, adds substantial research information to mathematics education policy.

I would now like to offer several recommendations and thoughts based on the findings of my research. As a researcher, I am constantly asking myself the same questions over and over again – what am I learning through this research process? What is there left to learn from my initial inquiry? And have I learned anything substantial in my inquiry? The former question is straightforward and quite redundant. At first the answer is obvious: more policy research is needed that questions the foundational philosophical assumptions inherent in educational policy. Since this work has only provided a small glimpse into the world of policy discourse, it is apparent that there are not only many questions left unasked, but also that there are also a multitude of other methodologies that would yield knowledge about policy that this study has not ventured into. One example would be ethnographic research that seeks to understand the ontological categories of mathematics, as they are present in a real classroom. Another could be a critical discourse analysis of the way media portrays the epistemological assumptions and ontological commitments of mathematics education. Certainly, research in any given area is unlimited, but this assertion leads us right back to the original question and the assumption latent in it: what is the purpose of researching mathematics education policy in a philosophical perspective? In other words, what am I trying to learn as a researcher of mathematics education?

The answer to the above question rests on two contradictory points; first, my own intuition which itself rests on years of study in philosophy of mathematics and mathematics education, and years of experience as a mathematics teacher. The second is my conviction that philosophy ought to be more apparent in the discourse of mathematics education and by doing so, education of mathematics would be better able to achieve the policy stated goals. Also, by making the philosophical parts of policy and mathematics more apparent, teachers will be in a better position to combat policy initiatives to best serve the needs of their specific population of students.

Yet another important question is: Does this dissertation provide the educational community with any useful information? The answer to this question is quite subjective. Certainly, as the sole researcher of this study, I have found a tremendous wealth of information that has been useful for me in thinking about mathematics education policy reform efforts. I believe two important findings emerged from this dissertation. The first is the ontological information that is present in policy documents about mathematics education. The second is the methodology, grounded in the theoretical understanding of philosophy of mathematics and Alan Badiou's philosophy. The analytic constructs that serve to guide the coding process can be extrapolated and utilized in other content analysis research. The set theoretical method once further elaborated upon can prove to be another useful mixed method approach to policy research. It is my hope that my work provides useful information for professional educators working in a highly political, stressful, and hopefully sometimes exhilarating environment. Given the very stronghold an absolutist conception of mathematics has on our society, it is worth uncovering the implicit ontological classification policy documents have about mathematical identities. Perhaps, if teachers gain the understanding of this implicit aesthetic nature of mathematics and the knowledge of how such a classification is also present in mathematics education policies, they can work from within the public school educational infrastructure to create meaningful positive change. Further work on conceptualizing what I have termed "pedagogy of the event" is needed to provide a useful and rich description of the type of teaching that can best foster not only a high level of cognitive understanding of mathematics, but also the critical awareness of the power and beauty mathematics holds on the modern western consciousness.

8.2. Pedagogy of the Event

Rarely are teachers depicted as agents of reform initiatives. Typically, they are discussed as either the cause of the problem in education and therefore in most need of educational reforms. As the policy documents indicate, reforms in mathematics education are targeting teachers for two reasons. One, policymakers are questioning the content language teachers have in mathematics and point to a deficiency, which they believe negatively affects international mathematics text scores. Second, teachers are being held responsible for the success of their students in learning high-level mathematics (measured mainly quantitative standardized tests), without reference to their students' social-cultural background and past educational experiences. In this high stakes climate of accountability for mathematics education, teachers are not to be ignored or insulted. In fact, it ought to be the top concern to give teachers the skills and knowledge they need to succeed in their mission as professionals providing high quality education to their student body and the communities they serve.

There are several important things teacher education programs and teachers ought to know. First, the state of the situation, i.e. what is specifically going on in educational policy and what complex interwoven discourses are being propagated that affect them and their students. Second, via Badiouian logic, teachers should be aware of how to structure their classrooms in such a way as to allow for the possibility of events to occur. Before teachers can begin to understand this latter crucial point, they must have a strong understanding of the policies that implicitly and/or explicitly affect their professional lives.

The state of the situation is a necessary knowledge base that teachers must have in order to be effective in the classroom and be fulfilled in their daily professional lives. After all, the attrition rate of new teachers is very high compared to other populations such as nursing. The National Center for Education Statistics (1994-1995) found that nineteen percent of new teachers leave the profession due to school staffing actions, such as cutbacks, layoff, termination, school reorganizations or school closing. However, forty-two percent give other reasons such as pregnancy or family issues.

Popkewitz defines reform as “an event that elucidates the productive nature of power rather than a solution to solve problems of teaching and learning" (Gabbard, 2000, p. 40). He goes further to claim that "this new discourse of reform creates new subjects of government and creates new relations between individuals and the way they are governed" (Gabbard, 2000, p. 39). However, reforms are not merely about power, but are about the philosophical assumptions embedded in them. Popkewitz argues that the various practices assembled in the alchemy produce the standards of reform. These standards are to be found not in the formal statements of principles and "outcomes" but in the distinctions and principles that produce a normalizing pedagogy (Popkewitz, p. 25). “The language of the mathematics reforms maintains this historical concern with governance through creating standards of comparison with regard to who the child is and should be” (Popkewitz, p. 7). This language of standards and “outcomes” also plays a significant role in creating teacher identities and thus pedagogical styles.

Since reform rhetoric is so complex in meaning, it is difficult for a teacher and/district to know their role not only in the implementation process, but also in the day -to-day happenings of their school and/or classroom. In some cases policy initiatives rarely influence the daily activities in a classroom; in other cases policies strongly influence them. An example of the former would be an affluent school in a suburban district on the east coast where their test scores are consistently above average and their teachers are provided with the support services they need to be successful. An example of the former would be a urban school with a high minorities and or low-income student population that is consistently testing below proficiency, where teachers leave the district after one year, and the state has threatened to shut the school down or replace it with a charter school.

Let us go back to Badiou's assertion that education is about organizing knowledge for some truth to emerge. This, according to Badiou, can only happen once a teacher absorbs expert knowledge of the situation as it is, which in this context encompasses knowledge of content as well as policy. Now, comes the difficult part, perhaps viewed as part pedagogical theory and part curriculum planning. How can a teacher plan for the unexpected – or in Badiou's language, for a truth event? Of course, that is impossible – you cannot plan for the unexpected. However, what you can do is welcome it, nurture it, and praise and glorify it when it does happen. This is the role of a teacher working in mathematics today.

A classroom is a type of microcosm and a dynamic space for chaos. Neyland (2009) writes that the element of surprise or as he calls it "discontinuities" are made more possible through "open learning communities." These types of organizational structures for learning are diametrically opposed to the linear model of teaching where the experienced professional teacher plans the lesson plan with a distinct set of activities in order to reach pre-established objectives. Neyland argues more for a "complexity" model in which the teacher acts more like an artist rather than a facilitator, where the structure of the lesson emerges through student and teacher interactions in the present, which cannot be nor should be predetermined. The rigidity in which mathematics teachers typically follow the curricula and their lesson plans needs to be questioned. Lessons need not follow the same predictable format and linear ordering year after year. This is monotonous for the learners as well as the educator. Moreover, this static unchanged mathematics epistemological tradition only serves to further divorce the intrinsic aesthetic dimension of mathematics from its education. Teachers can change this by incorporating current events in their lessons or tailoring the lessons to fit their current students' interests. At all times, teachers of mathematics ought to emphasis the beauty of mathematics, how it is a field that attempts to understand structures, patterns, and relationships all around us. They can do this by being themselves enthralled by the countless examples in mathematics from number theory to geometry. Examples like fractals, the Mobius strip, transcendental numbers like pi and phi, should serve as a infinite bag of concepts teachers can incorporate in their daily classrooms. After all, teaching area of a circle is a lot more engaging when students really understand the pi is not a constant their teacher asked them to memorize for a formula, but a variable that modern day mathematicians are still deeply curious about. Students who are given this type of aesthetic view of mathematics will not only enjoy it more, but hopefully learn it better as well.

Mazur (2003) speaks about the affective response in mathematical learning, which he calls the "a ha moment"; this occurs where an idea or abstract image finally becomes clear to the learner. In the classroom, teachers witness those "a ha" moments Mazur referred to. While these moments of sudden mathematical understanding happen for individual students unpredictably, it is the countless hours of struggle with learning new concepts and processes that came before which makes such moments possible.

Although these “a ha” moments can’t be planned, they can however be nurtured and given the space by which they can occur. What the teacher does to nurture this event before, during, and after it can be termed “Pedagogy of the Event.” What must not be forgotten here are that these events in the classroom are about more than just learning a high level of mathematics. They are about a deeper understanding of oneself in relation to the world around them. After all, mathematics, the meta-language of being, can teach us more than how to obtain a high-paying job or finance our next big purchase. Experiencing an aesthetic ontological conception of mathematics has infinite potential for changing the way in which our society uses mathematics and therefore has the greatest potential for changing our society itself.

8.3. Conclusion

As asserted elsewhere in this dissertation, mathematical knowledge is ubiquitous in modern society; this fact leads me to conclude that it is precisely within such an all-encompassing discipline that change has the greatest potential to emerge. The standardization and high stakes testing that has characterized policy reforms is not just about mathematics, but is mathematical insofar as it utilizes and is grounded on a particular ontological view of mathematics. Thus, if policy practices and ideologies can be questioned and viable alternatives can be made, then it can be due to a turn in the way we ontologically view mathematics.

Before alternatives can be envisioned and space for changes made, a strong comprehension of the policy discourse is necessary. Understanding of the situation is required, according to Badiou, for a subject to even have the possibility of being witness to a truth event. Since mathematics is the core of our knowledge as a society, it is vitally important for students to become fully knowledgeable about the core of its information, algorithms, processes, and methods**.** This statement may be disturbing for many learner-centered or social-constructivists educators since it does proclaim that a strong current western understanding of high-level mathematics is essential for every student. Nel Noddings wrote that not everyone needs algebra (Noddings, 2005). Other scholars have pointed to the exclusiveness and gentrification caused by mathematics education (e.g. Martin, 2003; Spillane, 2000). All these points are well founded, but the alternatives in mathematics education that follow from them are incomprehensible. Educators cannot chose to educate only a few “talented” students in mathematics, nor should they spend precise school time teaching long forgotten algorithms for multiplication. We cannot simply ignore the situation as it is presented to us nor can we hope to find a safe haven outside the state of the situation that cannot be influenced if not subsumed by the situation eventually. We live in a modern western central world here in the U.S., where mathematics is embedded in most products that we use everyday. A strong comprehension of fractions can not do any harm, but a misunderstanding of fractions can do massive amounts of harm, not only in the pursuit of finding gainful employment, and being a productive democratic citizen, but in the overall meta-cognitive understanding of one’s life, self, and world around him.

Amarthya Sen’s (2000) definition of human capital is "expansion of the capabilities of persons to lead the kind of lives they value and have reason to value” (p. 18). Reducing education to only serve workforce or economic demands lessens the way humankind has conceived of knowledge. Reducing learners or citizens to human capital, which are only necessary in terms of what capital they can produce for their nation, dehumanizes children and their families. It cheapens our values as a society and drastically reduces the possible social justice capabilities our education system can still, in my optimistic mind, create. On the other side, diluting education to erase the rigor and challenge in a discipline so highly influential to humankind would be a travesty. Luckily, the current national mathematics education policies have not set out to do any of the above. In fact, the policies seem to have opened a small space for positive changes in mathematics education to take place. Such changes have the potential to change our societal norms about mathematics, and the way it shapes our lives, for the better. Badiou says

> The philosopher is useful, because he or she has the task of observing the morning of a truth, and of interpreting this new truth over against old opinions. If « we must endure our thoughts all night», it is because we must correctly corrupt young people. When we feel that a truth-event interrupts the continuity of ordinary life, we have to say to others: "Wake up! The time of new thinking and acting is here!" But for that, we ourselves must be awake. We, philosophers, are not allowed to sleep. A philosopher is a poor night watchman (2006, p. 4).

The set theoretical analysis done at the end of Chapter 5 generated interesting and surprising findings. Connecting an aesthetic ontological view of mathematics with a transformative epistemology seems to be where a Badiouian event has the potential to emerge. To review, epistemological category believes knowledge is equal to power and that be teaching this axiom in mathematics education is crucial for developing the critical consciousness Freire and others critical theorists have strived for. The words that I found in policy documents that relate to this code are transformative, critical, awareness, power, empower. An example from one of the documents for this code is “Mathematics empowers us to better understand the information world in which we live“ (*Everybody Counts*). However, it is not clear if the way in which the word “empowers” relates to the way transformative epistemologies might envision it. Perhaps, this is not the point, especially in relation to policy documents, which are written in a more or less rhetorical format.

Given the research questions that grounded this dissertation study, I cannot offer further analysis on the link between transformative epistemology and a Badiouian event. However, what I can offer based on the findings generated from the set theoretical method I incorporate, is the conditions by which an event might occur, or where Badiou’s void might be found. Based on my analysis of the “state of the situation,” I must say that the void is located in transformative epistemologies that take into account all the interrelationship in the complex discourse of mathematics education policy reforms. Thus, it is not that transformative epistemologies can themselves elicit the events that have the potential to create subjects and radically change our society for the better; rather, it is the entanglement of an aesthetic ontologically view of mathematics with a subtle understanding of its historical and philosophical connection with the absolutist and fallibilist view of mathematics. All this must be coupled with an expert understanding of all the axiological claims made in policy discourses. According to my analysis, transformative epistemology, once it gets filtered through an ontological aesthetic way of understanding mathematics, has the potential to ignite an event, and thus to create a Badiouian subject; whether this subject is a mathematics teacher, a mathematics learner, or a mathematics education researcher only makes a difference in the way he/she interprets and chooses to act once experiencing such an "event." As Badiou himself confesses, a subject must always "wager" or "…decide upon the undecidable" (2000). In *Ethics* (2003b), Badiou theorizes a new type of universal ethics, one based on a subject remaining faithful to the truth event he/she has witnessed. Barbour (2010) writes:

> For Badiou, everything 'hinges on the possibility that some subject will encounter or experience some truth or experience some event and on the basis of that encounter or experience, be utterly compelled to decide a new way of being and 'invent a new way of acting in situation (p. 41- 42).

It is impossible to speculate about what kinds infinite possibilities can occur to shape this event, or about the type of subject that will emerge from witnessing it. All we know rom Badiou is that everyone has the universal capacity to witness a truth event if and when it emerges, but such an event is always contextual and tied to the subject's subjective experience and actions. Therefore, I can only use myself as an example: witnessing the policy analysis unfolds as it did for me in this dissertation was an event and I believe I emerged as the Badiouian subject of this event. The event being the excruciating hard work and meticulous collecting and coding of policy documents, which in the end revealed truths that I had not expected or could make sense of right away. My personal experience is tremendously rich and is continuing to unfold as I write these last words and submit this manuscript to my committee members. I can only say that I now strongly believe, and now have some empirical proof to validate my intuitions, that an ontological perspective is crucial to mathematics education, and has an important role to play in future research in mathematics education, as well as future pathways philosophy of mathematics education can take. More radically, I now see more clearly how my critiques regarding critical mathematics pedagogies was on the right track, yet needed much more expert knowledge that I am still in the process of gathering.

Revolution, for me, is not an antagonistic warfare but a subtle introspective creative process that although happens under the situation as it stands, slowly but surely erupts to change society completely. It is my knowledgeable conviction that once we begin to view the world as a collection of beautifully woven patterns or structures and gaining the knowledge that grants you the power to feel not only an integral part of such a world, but as an agent in transforming it, real lasting revolution will take place. But before that happens, I am content to continue working in the field of higher education, educating future mathematics teachers who will be on the front lines of policy decisions. Perhaps, it is here that my kind of subject is most needed and where revolutionary thoughts can flourish.

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Appendix

A. Philosophical Terms

Axiology

- "The branch of philosophy dealing with the nature of value and the types of value, as in morals, aesthetics, religion, and metaphysics." Webster's New World Dictionary, 2nd Edition
- http://www.cleardirection.com/docs/axiology.asp
- For education this is found in normative assumptions about what the purposes mathematics education ought to serve found in public discpourses and policy documents. (ends)

Epistemology

- The branch of philosophy that is interested in understanding knowledge, how we come to acquire it and whether it is fallible or valid beyond human understanding.
- For education, this is found in pedagogical theories on how best to teach mathematics, cognitive beliefs about how the human brian processes mathematical concepts, what are mathematics truths. (means)

Ontology

- The branch of philosophy that is interested in exploring questions of existence, being and reality. It askes waht the underlying components of reality are and what implicates these conceptions have on our place as humans living in a world we attempt to understand.
- For education, this is found in the underlying assumptions about what mathematical understanding can tell us about reality and how such an understanding influences the very way we perceive the world around us. (conceptualizations of mathematics)

B. Analytic Constructs

Policy Aims for Mathematics Education (axiological)

- Utilitarian
- Cognitive
- Democratic

Pedagogies of Mathematics Education (epistemological)

- Traditional
- Constructivists
- Transformative

Conceptions of Mathematics (ontological)

- Absolute
- Fallibilist
- Aesthetic

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D. The Riley Letters

D.1. From Mathematicians:

Dear Secretary Riley:

In early October of 1999, the United States Department of Education endorsed ten K-12 mathematics programs by describing them as "*exemplary*" or "*promising*." There are five programs in each category. The "*exemplary*" programs announced by the Department of Education are:

- Cognitive Tutor Algebra
- College Preparatory Mathematics (CPM)
- Connected Mathematics Program (CMP)
- Core-Plus Mathematics Project
- Interactive Mathematics Program (IMP)

The "*promising*" programs are:

- Everyday Mathematics
- MathLand
- Middle-school Mathematics through Applications Project (MMAP)
- Number Power
- The University of Chicago School Mathematics Project (UCSMP)

These mathematics programs are listed and described on the government web site:
http://www.enc.org/ed/exemplary/
The Expert Panel that made the final decisions did not include active research mathematicians. Expert Panel members originally included former NSF Assistant Director, Luther Williams, and former President of the National Council of Teachers of Mathematics, Jack Price. A list of current Expert Panel members is given at:
http://www.ed.gov/offices/OERI/ORAD/KAD/expert_panel/mathmemb.html
It is not likely that the mainstream views of practicing mathematicians and scientists were shared by those who designed the criteria for selection of "*exemplary*" and "*promising*" mathematics curricula. For example, the strong views about arithmetic algorithms expressed by one of the Expert Panel members, Steven Leinwand, are not widely held within the mathematics and scientific communities. In an article entitled, "*It's Time To Abandon Computational Algorithms*," published February 9, 1994, in Education Week on

the Web, he wrote:
"*It's time to recognize that, for many students, real mathematical power, on the one hand, and facility with multidigit, pencil-and-paper computational algorithms, on the other, are mutually exclusive. In fact, it's time to acknowledge that continuing to teach these skills to our students is not only unnecessary, but counterproductive and downright dangerous.*" (http://www.edweek.org/ew/1994/20lein.h13)
In sharp contrast, a committee of the American Mathematical Society (AMS), formed for the purpose of representing the views of the AMS to the National Council of Teachers of Mathematics, published a report which stressed the mathematical significance of the arithmetic algorithms, as well as addressing other mathematical issues. This report, published in the February 1998 issue of the Notices of the American Mathematical Society, includes the statement:
"*We would like to emphasize that the standard algorithms of arithmetic are more than just 'ways to get the answer'* -- *that is, they have theoretical as well as practical significance. For one thing, all the algorithms of arithmetic are preparatory for algebra, since there are (again, not by accident, but by virtue of the construction of the decimal system) strong analogies between arithmetic of ordinary numbers and arithmetic of polynomials.*"
Even before the endorsements by the Department of Education were announced, mathematicians and scientists from leading universities had already expressed opposition to several of the programs listed above and had pointed out serious mathematical shortcomings in them. The following criticisms, while not exhaustive, illustrate the level of opposition to the Department of Education's recommended mathematics programs by respected scholars:
Richard Askey, John Bascom Professor of Mathematics at the University of Wisconsin at Madison and a member of the National Academy of Sciences, pointed out in his paper, "*Good Intentions are not Enough*" that the grade 6-8 mathematics curriculum Connected Mathematics Program entirely omits the important topic of division of fractions. Professor Askey's paper was presented at the "Conference on Curriculum Wars: Alternative Approaches to Reading and Mathematics" held at Harvard University October 21 and 22, 1999. His paper also identifies other serious mathematical deficiencies of CMP. R. James Milgram, professor of mathematics at Stanford University, is the author of "*An Evaluation of CMP*," "*A Preliminary Analysis of SAT-I Mathematics Data for IMP Schools in California*," and "*Outcomes Analysis for Core Plus Students at Andover High School: One Year Later*." This latter paper is based on a statistical survey undertaken by Gregory Bachelis, professor of mathematics at Wayne State University. Each of these papers identifies serious shortcomings in the mathematics programs: CMP, Core-Plus, and IMP. Professor Milgram's papers are posted at: ftp://math.stanford.edu/pub/papers/milgram/ Martin Scharlemann, while chairman of the Department of Mathematics at the University of California at Santa Barbara, wrote an open letter deeply critical of the K-6 curriculum MathLand, identified as "*promising*" by the U. S. Department of Education. In his letter, Professor Scharlemann explains that the standard multiplication algorithm for numbers is not explained in MathLand. Specifically he states, "*Astonishing but true* -- *MathLand does not even mention to its students the*

standard method of doing multiplication." The letter is posted at: http://mathematicallycorrect.com/ml1.htm Betty Tsang, research physicist at Michigan

- State University, has posted detailed criticisms of the Connected Mathematics Project on her web site at: http://www.nscl.msu.edu/~tsang/CMP/cmp.html Hung-Hsi Wu, professor of mathematics at the University of California at Berkeley, has written a general critique of these recent curricula ("*The mathematics education reform: Why you should be concerned and what you can do*", American Mathematical Monthly 104(1997), 946-954) and a detailed review of one of the "*exemplary*" curricula, IMP ("*Review of Interactive Mathematics Program (IMP) at Berkeley High School*", http://www.math.berkeley.edu/~wu). He is concerned about the general lack of careful attention to mathematical substance in the newer offerings.

While we do not necessarily agree with each of the criticisms of the programs described above, given the serious nature of these criticisms by credible scholars, we believe that it is premature for the United States Government to recommend these ten mathematics programs to schools throughout the nation. We respectfully urge you to withdraw the entire list of "*exemplary*" and "*promising*" mathematics curricula, for further consideration, and to announce that withdrawal to the public. We further urge you to include well-respected mathematicians in any future evaluation of mathematics curricula conducted by the U.S. Department of Education. Until such a review has been made, we recommend that school districts not take the words "*exemplary*" and "*promising*" in their dictionary meanings, and exercise caution in choosing mathematics programs.

Sincerely,

David Klein Professor of Mathematics California State University, Northridge
John Bascom Professor of Mathematics University of Wisconsin at Madison
R. James Milgram Professor of Mathematics Stanford University
Hung-Hsi Wu Professor of Mathematics University of California, Berkeley
Martin Scharlemann Professor of Mathematics University of California, Santa Barbara
Professor Betty Tsang National Superconducting Cyclotron Laboratory Michigan State University

The following endorsements are listed in alphabetical order. (Large list of names)

Retrieved from http://www.mathematicallycorrect.com/riley.htm on Friday, March 29, 2013.

D.2. From NCTM:

November 30, 1999
Secretary Richard W. Riley
United States Secretary of Education
400 Maryland Avenue
Washington, DC 20202

Dear Mr. Secretary:

In light of the recent paid advertisement in the Washington Post requesting that you withdraw the list of exemplary and promising mathematics programs, the Board of Directors of the National Council of Teachers of Mathematics wishes to inform you of their unconditional support for the work of the Expert Panel, the criteria used by the Panel, the process employed by the Panel, and the quality and appropriateness of their final recommendations.
We are deeply disappointed that so many eminent and well-intentioned mathematicians and scientists have chosen to attack the work of the Panel. We note, however, that the advertisement represents the opinion of a small, but vocal, minority of mathematicians and scientists, many of whom have little direct knowledge of the elementary and secondary school mathematics curriculum nor how to make it responsive to the needs of all students.

Unfortunately, while NCTM is working diligently and successfully to engage mathematicians and mathematics teachers at all levels in the process of setting high standards for school mathematics, the authors of the Post advertisement seem determined unilaterally to undermine the programs that the Expert Panel has found to be exemplary and promising. We believe that the Panel took a hard look at quality, alignment with sound standards, and most importantly, how the various programs affect student learning. The ten programs recommended by the Expert Panel have already had a positive influence on thousands of young people. Thanks to work of the Panel, these programs can be expected to have an equally positive impact on millions of young people in the coming years. For reasons that we do not understand, this fact appears to seriously bother many of the individuals who allowed their names to be associated with the Post ad.
Mr. Secretary, NCTM's Board of Directors believes that the Department has performed a great service by providing this list of programs. We thank you and your colleagues for supporting the work of the Expert Panel and look forward to continuing to work with you on behalf of the mathematics education of our nation's youth.

Sincerely,

John A. Thorpe
Executive Director